INSTITUTE OF EDUCATION FOR WOMEN
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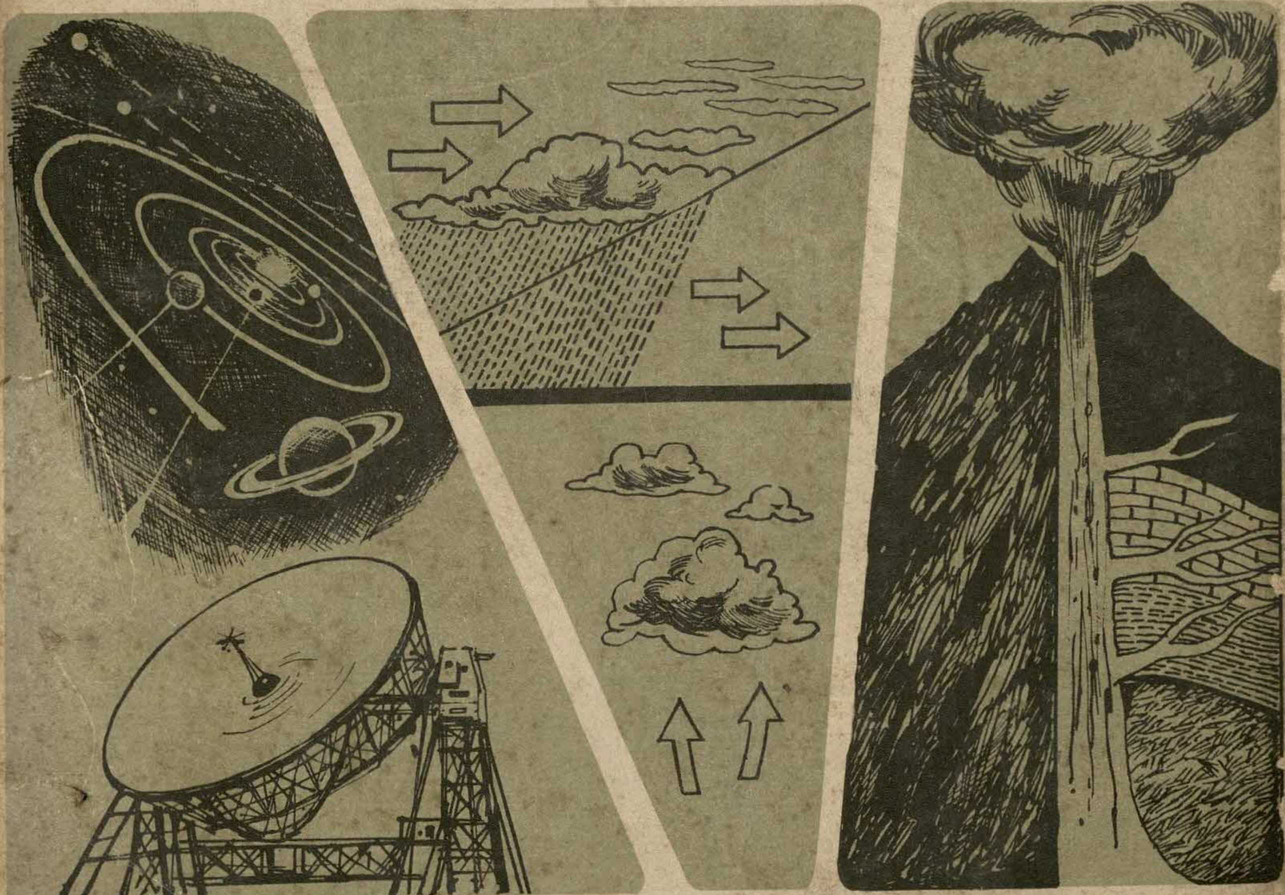
# GENERAL SCIENCE

## FOR PRIMARY SCHOOLS 1

## A TEACHERS HANDBOOK OF ACTIVITIES



NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

# GENERAL SCIENCE
*for*
Primary Schools

*Teacher's Handbook of Activities*

VOLUME ONE

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NATIONAL COUNCIL OF EDUCATIONAL RESEARCH AND TRAINING

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# FOREWORD

Education in a developing society like ours faces a challenging task, particularly if it is not restricted to a social class. On the one hand, it has to trasmit the tradition and heritage of the land and its people in a manner which is acceptable to the masses brought into the stream of education by the process of increasing democratization; on the other, it has to function as an instrument of social change. An important factor in social change being science and technology, our schools should provide adequate instruction in science the aim of which should be to teach the method of scientific inquiry as much as the knowledge of scientific principles and facts. Hence in 1963, the National Council of Educational Research and Training developed as a first step, an all-India syllabus in general science for classes I-VIII with the help of several groups of science teachers, teacher educators and science supervisors. For each area or unit of study a number of major and minor concepts were listed as a core for the development of scientific understanding of the environment. In order to help the teachers of the middle school level in developing such understanding in their pupils, a *General Science Handbook of Activities: Classes VI-VIII* was published in 1964. Our approach in the primary stage is however somewhat different. Here an attempt has been made to give to the teacher some knowledge of the concepts as well as the guidelines for using an investigatory or inquiry-based method of teaching science.

It is hoped that the present volume will help the teacher to develop new insights into science and scientific method and enable him to provide to the young child under his care some meaningful learning experience.

Shib K. Mitra

New Delhi
17 October, 1967

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# INTRODUCTION

This teacher's handbook is intended to help teachers of primary schools to use science effectively as part of the curriculum. The handbook is written for the primary school teachers of India, especially those who have not completed high or higher secondary school and have little or no background in science.

A primary school teacher teaches in the regional language in the village school, where there are one, two or perhaps three teachers. He teaches in a small room of a simple building; his students sit on the floor. He may or may not have suitable textbooks in science; his budget for purchasing science materials is almost zero. Yet it should not be assumed that the village teacher in India has no resources for the teaching of science. Rural children here are very close to their environment. They are surrounded by plants and animal life on their farms and in their hamlets. They are more aware of weather, climate, of water supply and problems of keeping cool than are children in larger cities.

At an early age they have learned about fuels as sources of heat and light, and about the nature of the night time sky. Many primary school children have had abundant experience in carrying on household tasks and village activities which involve the principles of science. Thus in many ways, the rural children of this country, like those of many other countries, have a remarkable start towards learning about science.

Although village schools have little or no special equipment for the teaching of science, they have many useful resources on which they can draw. There is science involved in everyday food, clothing and housing. Many science principles are illustrated on the farms, in the kitchens, and in the village bazars. Many everyday items, such as earthen pots, electric torches, glass jars, string and paper, rocks and soils, can be used to help teaching science.

It is the purpose of this handbook to help the teacher who is inexperienced in science teaching. The teacher can make use of children's experiences with everyday materials in teaching scientific principles as well as the nature of science.

### Why teach science to children?

The effective way to approach the answer to this question is to analyze what is the nature of science and what is it that scientists do? Unfortunately there are wide misunderstandings about these things. There are many who believe that science is simply a collection of theories and principles, facts and formulas, special methods and scientific names. They believe that a scientist is one who has learnt all such things and is prepared to draw upon his memory in his scientific work. This description is far from accurate. Science is more than a collection of knowledge; it is also the intellectual activity in which scientists are engaged. That is, science is not just a subject—it is also a pattern of methods for solving real problems, large and small, scientific and otherwise.

Science is also a set of attitudes about doing things and about thinking—a background of appreciations of the natural and man-made environment. When scientists work, it is true that they draw upon what they have learnt in the past. Yet memorization is not their most valuable asset. The best of human memories often fails. New ideas of science are developed very rapidly long after a scientist has finished his university training. Very typically the scientist is called upon not simply to recite what is known, but rather to find out what is not known. Thus the work of a scientist is far from being a matter of repeating learned knowledge. Research is much more of a creative process where the scientist finds new knowledge or applies existing principles to new situations.

Science does involve the learning of knowledge and of skills. But this is only a part of science. Another important aspect of science includes the methods scientists use to gain new knowledge, the attitudes involved in their behaviour. Science also includes the activities of scientists, and the role of science in society. Science is not merely what scientists know; it is also what scientists do.

These two aspects of the scientific enterprise are described in many terms: 'subject' and 'method', 'content' and 'activities', 'knowledge' and 'behaviour'. A well accepted pair of terms is used throughout these pages—'product' and 'process'.

What is meant by *product of science?* This is the side of science familiar to most teachers and students the world over. This is the side which is basically knowledge, including facts and figures, formulas and equations, principles and scientific laws. This is, indeed, the side of science to which most teaching effort in most countries has usually been directed.

By *process of science* is meant the things that scientists do. This includes the way they locate information in books and magazines, the way they learn through observation, the way they experiment (that is, manipulate the environment for purposes of special observation). This also means the way they develop ideas of what *might* be true, the way they test these ideas, and the way they communicate the ideas to others. This is the sort of thing often referred to as *scientific methods*. Not only scientists, but all men and women and boys and girls can become more successful, more satisfied individuals if they have competence along these lines.

Process of science also includes the patterns of thinking sometimes called *scientific attitudes*. This means curiosity, honest doubt, tolerance for the opinions of others, and suspension of judgement. This also includes willingness to admit when one is wrong, and an inclination to make decisions on the basis of evidence rather than tradition, superstition, or emotion. People—scientists and others—are better off if they act in these ways.

Process of science also means the role of the scientific enterprise in a modern nation. This includes the part to be played by science in improving agriculture, health, industry, communication and transport of a country. It means the function of science is to improve general standards of living and help establish personal and national security. Perhaps most of all, it means the thing that science and scientists do—they seek satisfying explanations for the things they observe. Seen thus, science is a specialized kind of curiosity, a highly intellectual enterprise in which each and all can participate, each at his own level.

If this is the modern concept of what science really is, what has it to do with Indian children at the primary school level? There are two kinds of ways in which science affects these children.

For one thing, these children are affected as individuals growing up in a modern world which is very different than it was even one generation ago. These children are affected by much of the progress which science has brought. They use plastics, synthetic fibres and medicines which were almost unknown when their parents were young. These children are directly affected by new means of communication such as telegraph, radio and cinema and also by better methods of transportation. These children are affected by fertilizers and hybrid seeds for better crops, by irrigation and other improved methods of farming, by new standards of sanitation. They are affected by the need for population control, and by new kinds of tools and machinery, electricity and chemical power, which are being increasingly used in their daily lives. A child growing up in this changing world must learn about these new features of his environment.

Children are also affected by the ways in which scientists work. In a very real sense children must be their own science specialists. Children need to find out new information, they need to arrive at an understanding of what is going on about them, they need to make judgements and decisions concerning what they will do in many walks of life. These tasks of children are very close to the activities of scientists. Thus the *process of science* as well as the *product of science* are things which are extremely important to very young children.

There is yet another way in which science affects people through the impact that it has on the society in which they live. Improved means of communication and transportation are helping to bring even the most remote village into some kind of contact with the rest of the world. Increased production of goods and better demand for human services are changing not only our standard of living but also our patterns of daily activities. The over-crowding of population brings a new and imperative need for national efforts on birth control.

It is much more difficult for a modern child to understand science in its broadest sense than it was even a few years ago. While it is true that there is far more science to be learnt today than there was a generation ago, this is not what makes modern science learning such a large task. Rather the learning of science today is difficult because it is so complicated. The modern young person must not only know some principles of science, he must know how to apply them and he must know how to find new information when he needs it.

For these reasons we must start children on their task of learning about science as early as possible. There is ample evidence to show that children at pre-school age can learn some simple principles of science. What is more important, they can use the process of science effectively. For example, most of what children learn until they are three or four years old is learnt strictly through observation and experience—the basic tools of the laboratory scientist! Pre-school children can acquire important attitudes about science—attitudes such as curiosity, tolerance of others' ideas, and respectful doubt of established authority. The sooner we start teaching science to young children the better. At the present level of the development of primary school education in this country, the best that can be done for all children is to start with class I.

### How should science be taught?

A valuable tool for methods of teaching science can be found in the analysis of science on the previous pages. If science is *process* and *product,* then it should be taught as such. If it is true that sheer memorization of facts and principles is not of supreme importance to a scientist, then science should not be presented in this way to children. If it is true that problem solving, decision making, creative curiosity, and effective inquiry are fundamental features of science, then these kinds of activities should be abundantly present in school science for children.

This does not mean that science teaching should not include knowledge. What it does mean is that knowledge is to be *understood* rather than merely memorized. It does mean that not all knowledge known to scientists can be included in the curriculum. Rather one must select those ideas in science which will be most useful to young people. Furthermore, the selection of science subject matter should be made in terms of broad understanding which ramify throughout human experiences. These broad understandings are often referred to as 'conceptual themes'. These are broad and sweeping ideas which cut across the conventional compartments of subject matter. These ideas have application not only in scientific laboratories but also in the daily lives of common people. The following list of fifteen conceptual themes is typical of this new approach to the selection of subject matter.

1 Every effect has its cause or causes.
2 Scales for time, position, size, and motion in space are relative, not absolute.
3 Natural laws are universal, demonstrable through time and space.
4 Dissimilarity and diversity are normal qualities in natural phenomena.
5 In spite of natural diversity, there are patterns of similarity among things in the universe; they are amenable to useful man-made system of classification.
6 Change is a normal condition in the dynamic continuity of nature.
7 In spite of natural change, the influence of heredity tends to maintain characteristics of living things from one generation to the next.
8 Interdependence and interaction with environment are universal relationships in nature.
9 Matter is particulate in nature.
10 Energy interchanges accompany every natural occurrence.
11 Energy can be transmitted in a variety of forms and manners.
12 Fields of influence extend beyond the place of their origin.
13 Equilibrium is a condition towards which all systems in the universe tend to evolve.
14 Living organisms are highly specialized systems of matter and energy.
15 The sum total of matter and energy in any isolated system remains constant.

These conceptual themes have been deliberately woven into this handbook. At many points throughout the pages of the guide, specific reference is made to one or more of them. The suggested learning activities and the selected special sections for the teachers (For Better Understanding) focus attention on these conceptual themes and suggest to the teacher ways in which he can make them understandable to students

### What are the characteristics of children?

The science of educational psychology is adding much to the experience and wisdom of adults to help us understand better the nature of young children and the ways in which they learn. The interests and attitudes of young children vary with their age. Sometimes these characteristics vary with the environment—rural or urban—in which they happen to be placed. The atmosphere in the family and the school also contributes to their development.

A six or seven-year-old child usually shows signs of self-assertion and hates imposition by others. He is extremely inquisitive and wants to explore, feel, touch, and use all his senses. He has a keen sense of competition and wishes to outdo his peers. He fondles young animals and tries to make friends with them. He collects things such as clay, bricks, stones in the environment. He engages himself and his peers in make-believe construction, cooking and other activities. He likes to play with toys. He attempts to make them and destroy them soon after. His attention span is about fifteen minutes. Encouragement helps him a lot in his endeavours and investigation.

Very careful handling by parents and teachers is needed to develop and mould the character of a child of this age. He should not be burdened with tasks which he is incapable of doing. He needs careful and close supervision in the classroom. As his attention span is small, it will be helpful if two or three activities of different types are put into a single class period of 30-35 minutes.

The eight-year-old child just begins to think logically and makes an honest effort to express himself properly through the media available. He begins to distinguish facts from fiction. Usually, he has a great deal of energy which is manifested through physical exercises. He runs when he could walk. This energy should be properly channelled for useful purposes through activities of various types in which the child often takes great interest.

The nine-year-old child starts developing his own interests. He is less dependent on his teachers and elders than when he was younger. He can understand simple relationships of time and space and appreciate the past and the present. Often he does not accept a statement unless he really believes it. This is, therefore, just the stage when he should be directed to plan ways to find answers for the questions that he raises.

The ten-year-old child is capable of doing some rather critical thinking. He continues to be inquisitive and takes great pleasure in experimenting and finding out new things. At this age he develops special interests and likes to work in groups. He is more mature now and can understand more complicated relationships than when he was younger. He takes interest in reading books on adventure. He is increasingly able to appreciate the role of scientists and scientific achievements.

### What is known about how children learn?

It is known from research in educational psychology that children do not learn best by simply being told. Rather, they learn better when they are personally involved in activities related to the subject at hand. Briefly, children learn by doing; so do adults. It will always be necessary for students at any age level to learn much knowledge by reading it or by listening to it. Wherever possible, however, teachers should plan their programme in such a manner that children have a chance to *learn through activities.* Teaching science is not 'telling science'. Teachers need to provide rich variety of real learning experiences through which children can learn. Learnings acquired in this way are more meaningful and less forgettable than learnings acquired merely through listening and reading. Wherever possible, teachers should try to help students develop ideas about science on the basis of first-hand evidence.

Educational psychology has clearly shown that learning on the basis of meaningful activities leads to better understanding of scientific principles and to permanent learning of related facts. It is also obvious that this pattern of learning helps children learn not only the product but also the process of science. After all, the development of principles based on first-hand observation is thoroughly characteristic of the process of science.

The activities of this handbook are selected and described in such a way as to emphasize this kind of learning. At the same time, they are selected in such a way that they will lead to a knowledge of facts and an understanding of principles of science. In this way, the teaching of *science product* through an approach which emphasizes the *science process* makes for better overall learning of science from the broadest possible point of view.

This teacher's handbook is *not* intended as a course of study to be rigorously followed. Furthermore, this guide is *not* a set of lessons to be used by the teacher. Rather, the handbook is intended as a teacher's resource, a collection of ideas to which he may refer for improved teaching of science to his children.

It is very clear that patterns of teaching science vary throughout the nation. Certainly they differ from state to state, from district to district, and from school to school. The purpose of this teacher's handbook is to help each individual teacher develop the local pattern of science teaching to new levels of effectiveness.

**What syllabus does this teacher's handbook follow?**

This handbook is structured on the basis of the "General Science Syllabus—Classes I-VIII" published by the National Council of Educational Research and Training in 1963. There have been some modifications in the details of that syllabus, and correspondingly in this handbook. A few such examples are given below :

1 The unit on 'Energy and Work' has been rewritten and enlarged. This has been done because of the conviction that concepts of energy and work are too important to postpone until class IV. Fortunately many of these concepts can be understood by children in the first three classes. Accordingly this unit has been enlarged and distributed among all of the first five classes.
2 The unit on 'Matter and Materials' has been given a treatment similar to that of the unit on 'Energy and Work' for the same reasons. This, too, has been enlarged and distributed among classes I through V.
3 The unit on 'Scientists at Work' has

been distributed among all of the units of the syllabus. It is felt that the accounts of scientists' activities are more meaningful if they are taught in conjunction with a related conceptual theme or an appropriate unit of work.

4 The unit on 'Measurements' has similarly been redistributed among appropriate units. Most of the concepts formerly in that unit are now found in the units on 'Our Universe', 'Air, Water and Weather', 'Energy and Work', and 'Matter and Materials'.

In spite of these modifications in the 1963 General Science Syllabus, the teacher will have no difficulty in using this handbook to teach the older version of the syllabus.

Thus the thirteen units of the original "General Science Syllabus Classes I–VIII" have been reduced to eleven in number. For purposes of this publication these eleven units have been rearranged into three major sections. These sections are bound into three separate volumes, of which this is one. These three new volumes, the new arrangement of units and their new numbers are shown in the chart below:

VOLUME 1—THE EARTH-RELATED SCIENCES

Unit 1—*Our Universe* (formerly Unit 12)
Unit 2—*Air, Water and Weather* (formerly Unit 1)
Unit 3—*Rocks, Soils and Minerals* (formerly Unit 2)

VOLUME 2—THE PHYSICAL SCIENCES

Unit 4—*Energy and Work* (formerly Unit 6)
Unit 5—*Matter and Materials* (formerly Unit 7)
Unit 6—*Housing and Clothing* (formerly Unit 5)

VOLUME 3—THE BIOLOGICAL SCIENCES

Unit 7—*Living Things* (formerly Unit 8)
Unit 8—*Plant Life* (formerly Unit 9)
Unit 9—*Animal Life* (formerly Unit 10)
Unit 10—*Human Body, Health and Hygiene* (formerly Unit 3)
Unit 11—*Safety and First Aid* (formerly Unit 4)

Thus this three-volume edition of "Science for Primary Schools—a Teacher's Handbook" is arranged into three logical sections. However, this does not imply that children are to be led in their science learnings through this kind of subject-matter organization. This highly logical subject-matter organization appeals to the view of the scientist and meets the needs of curriculum workers and classroom teachers. However, it does not represent the interests of children nor the ways in which they learn.

**How can this handbook be useful?**

Each class level of each unit is introduced by an overview. This is intended to help the teacher to see what is involved in this unit at this class level, to realize why it is important in the education of children, and to learn what students already know about this unit.

Each of the eleven units of work at each class level is divided into major concepts. Each major concept is in turn broken into sub-concepts. The organization of the teacher's handbook is on the same pattern Each sub-concept begins with a brief statement concerning the knowledge and understanding involved. This is intended as a condensed lesson for the teacher. Next appear one or more learning activities which are useful in helping students understand the sub-concept. These learning activities are of several types such as:

Investigation
Discussion
Class Project
Field Observation
Interview
Familiar Experience

Whatever the type of activity, it is printed in a heavily starred box for easy identification. This heavy box includes the title of the activity, the materials needed, the instructions for carrying out the activity, and often an illustration.

In addition, each sub-concept contains one or more additional activities briefly suggested. These are printed in a lightly dotted box for easy identification. Unlike the heavily boxed activities, these are merely quick suggestions without detailed instructions.

A special kind of learning activity—'Scientists at Work'—appears several times in each unit. These selections are located immediately after an appropriate sub-concept, or at the end of a class level. Each 'Scientists at Work' activity is basically a story for children. It is intended that the teacher should read the story for thorough understanding; then he should relate it to the students using his own words and style of presentation. This is a much better procedure than simply to read 'Scientists at Work' to the class.

In many places the teacher needs additional background over and above what he might teach to children. This has been included, where needed, under the heading 'For Better Understanding'

**Where can teachers get help for science teaching?**

It is hoped that this handbook will interest teachers throughout the nation in a serious attempt to improve science teaching. If you are so interested, you will surely need additional help. Here are some of the ways in which you can seek and find such assistance:

(a) Keep your eyes open to the everyday materials familiar to children. Once you know how to look for such materials, you will find that some of the most common and ordinary things in daily life can be used to teach science very effectively. You will find many examples of such use of common materials in the boxed activities of this handbook. With practice you can learn to find and use many more.

(b) Take advantage of experts in the community. Although they may not have national fame, there are genuine experts in many fields in every community. There are successful farmers and good cooks; there are experienced merchants and skilful mechanics. Many parents are experts in some everyday field related to science--a field such as the making of thread and cloth, or the maintenance of carts and other farm tools. Nearby there are doctors, merchants, tailors and potters, health officers, district development officials, and the like. Take every opportunity to have such people come to your class or to have students seek them out and visit them where they work. In this way, children will not only learn the related science but will also learn much of value about their own community.

(c) Take full advantage of inexpensive

printed materials such as newspapers, magazines, and books.

(d) Consult the science teaching experts from the State Institute of Science or the State Institute of Education to get such help as you can. Most of these specialists are located in the state capital, but make frequent trips throughout the states. Write to them and seek their assistance.

(e) Contact extension centres for primary education and the teacher training colleges nearest to you. Each of these institutions has one or more experts in science teaching. Usually they can provide assistance if you specifically ask for it.

**What is there to read?**

Here is a selected bibliography of publications about science and science teaching. It is designed to include materials which are readily available and relatively inexpensive.

## Bibliography

The teacher who earnestly seeks to improve his science teaching programme needs many kinds of help. Among other things he needs books—books about science content, and books about ways of teaching science.

Many teachers in our country have difficulty in finding suitable books to help them teach science better. Although such books are not as plentiful as they should be, the situation is getting better. The lists which follow include books which are not only of great value to the primary school science teacher but are also apt to be available to him.

### UNIT 1—OUR UNIVERSE

1. Grey. *The First Book of Astronomy* Franklin Watts, Inc., New York.
2. Nicholson, Thomas D. *The Adventure Book of Stars.* Capital Publishing Co., Inc., New York.
3. Parker, Bertha M. *Basic Science Education Series.* Evanston, Row and Peterson.
   Beyond the Solar System
   Earth's Nearest Neighbour
   The Sun and its Family
   The Sky above us.
4. Wyler, Rose and Ames. *Golden Book of Astronomy.* Simon and Schuster, New York.
5. Zim, H.S. and Baker, R.H. *Stars.* Simon and Schuster, New York.

### UNIT 2—AIR, WATER AND WEATHER

1. Barnard and Edwards. *The New Basic Science.* Macmillan & Co., New York.
2. Brooks, Tracy and Tropp. *Modern Physical Science.* Holt, Rinehart and Winston, New York.
3. Gorden Cook. *The World of Water.* The Dial Press, New York.
4. Parker, B. M. *Basic Science Education Series.* Evanston, Row and Peterson.
5. *Weather and its Forecasting.* Meteorological Department, Lodi Estate, New Delhi.
   Ask the Weatherman
   Clouds, Rain and Snow
   Our Ocean of Air
   Ways of the Weather.

### UNIT 3—ROCKS, SOIL AND MINERALS

1. Krishnan, M.S. *Geology of India and Burma.* Higginbothams (P) Ltd., Madras.
2. Patrick Moore. *The Earth.* Muller, London.

3. Pearl, Richard M. *Rocks and Minerals.* Barnes and Noble, New York.
4. Podendorf, Illa. *Rocks and Minerals.* Muller, London.
5. Taylor, N. A. *Rocks and Fossils.* Vista Books, London.

GENERAL

1. Arey, C.A. *Science Experiments for Elementary Schools.* Bureau of Publications, Teachers College, Columbia University, New York.
2. Blough, Schwartz and Huggett. *Elementary School Science and how to Teach it.* Dryden Press, New York.
3. Joseph, E.D. *Teaching of Science in the Tropical Primary Schools.* Oxford University Press, London.
4. Little, W.B. *General Elementary Science.* Pitman and Sons, Ltd., London.
5. *Resource Materials Elementary Science.* Concordia Publishing House, St. Louis, Missouri.
6. Science Masters Association. *Report on Teaching of General Science.* John Murray, London.
7. *Unesco Source Book for Science Teaching* (available with prominent booksellers).
8. Verstraeten and Watts. *Science in Everyday Life,* Teaching Manual. Orient Longmans, Calcutta.

# UNIT 1

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# OUR UNIVERSE

## CLASS I

### Overview

Every normal child entering class I is fully aware of the existence of the sun, the moon and the stars. He has definite, although limited, bits of knowledge about these objects in the sky. He knows that the sun is bright and that it is hot and that it is seen only in day-time. He knows that the moon is much dimmer, and he usually associates it with night-time. He knows that the stars seem very small and very far away, and that they are seen only at night. Some of these things he may have been told, but all or most of them he has learned through his own observation.

In class I, the teacher should try to review these observations, and help the student realize that he is already finding things out for himself. There is no attempt here to teach children why the skies appear as they do. For now it is enough simply to make these observations, and to bring the child's bits of knowledge into some kind of conscious organization. Children should finish class I with some simple knowledge about the sun and the moon and the stars. They should know when to expect to see these heavenly objects, and in what general part of the sky they are to be seen. They should be aware of the cause-and-effect relations between sunlight and day-time. They should begin to have a conception of the directions, east and west and possibly north and south as well.

Throughout this unit at this class level there are two major scientific ideas. One of these is that of *variety*. There are different kinds of objects to be seen in the sky. There is a variety of stars, both in brightness and in colour.

The second major thought in this class level is that of *change*. Each of the objects in the sky changes. The sun changes its position. When near the horizon, it appears more yellow or even red, and also appears to be larger. The moon is not only seen in different places, it also appears to have different shapes. Even the stars undergo changes. They change their position hour by hour. Many of them change while they are being watched—that is, they twinkle.

*Variety* and *change* in nature and man's ability to learn through his own *observations:* these are the 'big ideas' of this unit at this class I level.

### 1. THE SUN, THE MOON AND THE STARS ARE IN THE SKY

Children are very interested in the sky. They see many things there. They see leaves and papers blowing in the breeze. They see birds and insects, and sometimes aeroplanes Yet they think of these not so much as being in the *sky*, but as being in the *air*. Children also see clouds; sometimes they correctly think of them as being in the air too. But sometimes they think of them as being in the sky—along with the sun, the moon, and the stars.

While birds and aeroplanes and clouds are really inside the earth's atmosphere, the sun, the moon, the stars, and the planets are not. In this major concept, 'things in the sky' are considered to be those which are astronomical objects. Children see these things, of course, and are curious about them. Part of learning science is to learn about the objects in the sky, to understand something of their movements, and to have a measure of enjoyment from seeing and understanding these things.

### **1 (a).** THE SUN IS SEEN DURING THE DAY

Adults know that the sun produces daylight, and that when night comes, it is because the sun is on the far side of the earth. Yet small children often assume that day and night 'come naturally', and that the sun 'just happens to be there' during the day-time. After all, they might reason, day-time comes on cloudy days too, when the sun cannot be seen. Furthermore, during a bright day, the sun is at one spot in the sky—but the sky is *entirely* bright, and it is daylight *all over*, as far as the child is concerned. Here are some simple activities which can help young children understand the relationship between the presence of the sun in the sky and the occurrence of daylight.

**Investigation**

**Are lights needed in the day-time?**

Ask a child to turn on the light in the school room during the day-time. Let the children discuss and decide whether it was necessary to switch the light on when the room was already well illuminated. Let them find out whether switching on the light adds in anyway to the visibility in the room. Help them relate this to the presence of the sun in the sky. When there is the sun in the sky, there is no need to light a lamp. It is day-time.

*Encourage children to consider what it would be like if the sun were to appear in the middle of the night.*

*Let children experiment by using a lighted candle or an oil lamp or a pocket torch—all in the day-time.*

### 1 (b). THE STARS ARE SEEN AT NIGHT

The stars give off light. They give light during the day as well as at night. But compared with the sun, they look dim. That is why they cannot be seen during the day. Their light is like the light of a candle burning in bright sunlight. The stars are really very big and very bright. Some of them are many times bigger than the sun. But they are extremely far away. That is why they appear dim and can be seen only when there is no sun in the sky. The activities suggested below will help make this clear to young children.

**Investigation**

**Why are stars seen only at night?**

*Materials required*
**bright light source, incense**

Let children arrange a powerful light at one corner of a darkened room. Let some child light the petromax. Ask a child to ignite an incense stick (agarbatti) and hold it near the bright light as in Fig. 1-1. Let some children go to the far corner of the room. Ask them whether they were able to see the glow on the stick clearly. Let them find out the answer as to why they could not see it. Now put out the light. Let them see that the glowing stick becomes clearly visible. Why was it so? Let them discuss and find out. Help them compare this situation with the sky during the day and the sky at night. Help them thus understand why the stars are seen only at night.

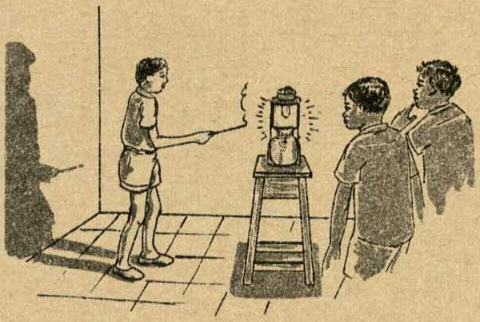


Fig. 1-1
It is difficult to see a dim light when it is very near to a bright light.

**Familiar Experience**

**Can stars be seen when there is a bright light in the sky?**

Remind children of a common experience they have all had at night. On a clear night, the stars are easily seen from out in the fields. But when they walk into the bazaar, there are many bright lights in the street. Now it is difficult to see any but the brightest stars. Yet all the stars are still there.

It seems that even if only a small part of the 'sky' is brightly lit, the stars do not show up well. In a similar way, when the *entire* sky is very brightly lit by the sun, the stars cannot be seen at all.

*Remind children how pale and dim the stars seem when the moon is bright.*

*Point out to children how the flame of a candle or of a matchstick seems very dim in the day-time. Yet it is just as hot and really gives off just as much light as at night when the candle seems so much brighter.*

**1 (c).** THE MOON IS SEEN AT NIGHT AND SOMETIMES DURING THE DAY ALSO

The moon is clearly visible at night because there is no sun in the sky then. Sometimes in the evening and in the morning, it is possible to see the moon. But it looks quite pale. When the moon is seen in the day-time, it is usually in that general part of the sky away from the sun. If it is seen in the morning, it is in the western sky. If it is seen in the afternoon, it is in the eastern sky. The important thing, however, is to help children realize that the moon is bright enough to be seen even when the sun is in the sky. Here are some suggested learning experiences to achieve this end.

**Investigation**

**Can a bright light be seen in the day-time?**

*Materials required*
torch or other bright light

Take children out when the sun is shining brightly. Let a child switch on an electric torch. Ask a few children to move some distance away. Let them find out whether they are able to see the torch light during the day-time.

*Sometimes when the moon is visible during daylight, call it to the attention of the class. Note that the moon is nearly opposite the sun in the sky.*

### For Better Understanding

The sun and the stars are enormous sources of energy. As a result of complicated reactions inside them, they give off fantastic quantities of heat and light energy. They are not really 'balls of fire' in the strict sense of the word. They are far far larger and hotter and brighter than any 'fire'.

The moon, on the other hand, is a cold, quiet sphere. It shines by reflected sunlight. If the sun were not shining, the moon would be invisible.

The idea that the moon shines only by reflected light is used in many other concepts in this and latter classes. This is a good place to help students begin to acquire this understanding.

## 2. THE SUN RISES AND SETS EVERY DAY

With sunrise, the day begins. The day ends with sunset. With sunset, the night begins. Night ends with sunrise. In the morning, the sunlight comes into the house through the same windows and doors every day. In the evening, it comes in through windows and doors on the other side of the building. Time is figured from the apparent movement of the sun. The sun, and the cycle of day and night, regulate most of the things people and animals do.

### 2(a). THE SUN RISES EVERY DAY IN THE SAME GENERAL DIRECTION (EAST)

Except when the sky is cloudy, children can notice the sunrise at least once a week on Sunday, when they have no morning school. In summer, it can be an everyday experience. The important thing is that sunrise occurs in the same general region of the sky every day. Children can be helped to observe sunrise and discuss it amongst themselves and with their teacher. Here is a way to get children to have such experiences.

**Field Observation** **When and where do we see the sunrise?**

Ask children to get up at the time of sunrise; their parents can wake them up. Tell them how beautiful the rising sun is, and thus arouse their interest and sense of beauty. Ask them to find out through which windows and doors the early morning sunlight comes into their houses. Let them do this for a number of days and report back to their classmates and teacher. They can thus find out for themselves that the sun always rises in the same direction every day. Let them learn, through you, the name of this direction (east).

*Whenever you take children out for morning games, etc. ask them to look at the sky. Help them notice the position of the sun From this they can tell which direction is east. They can also tell whether it is early morning or nearly noon.*

### 2(b). THE SUN SETS EVERY DAY IN THE SAME GENERAL DIRECTION (WEST)

Children can see sunset many days of the year. As they have already learnt through their own observations that the sun always rises in the same general direction, it is now easy for them to grasp that the sun sets in the same general direction each day. Furthermore, this direction is opposite to the east. Children are fond of colours and at the time of sunset there is a feast of colours in the western sky. An approach to the observation of sunset can be arranged in ways such as these .

**Excursion**

**Let us go and see the sunset**

Take children for an evening walk. Ask them to look at the setting sun. Draw their attention to some prominent landmark so that children can see if the sun sets in the same region of the sky each evening. Let them see for themselves that the sun sets in the same region of the sky. Help them realize that this part of the sky is opposite of the east. Help them learn the word 'west'.

*Encourage children to draw simple pictures of the sunset. Display coloured pictures of beautiful sunsets.*

### 2 (c). THE SUN RISES AND SETS EVERY DAY CAUSING DAY AND NIGHT

Children are already familiar with the terms day and night. They also know that the sun appears in the sky only during the day and never at night. Only the moon and the stars are seen in the sky at night. They have learnt the *facts* of sunrise and sunset. What is now needed is to help them *coordinate* these facts and organize their knowledge. Children need help in establishing the relation between sunrise and sunset on the one hand, and day and night on the other. This may be done in the following manner.

**Discussion**

**What is the relation between the sun and daylight?**

Review with children the facts of sunrise and sunset. Remind them that the sun is seen during the day, and the moon and the stars at night. Help them inter-relate these facts. Help them recall that day begins at sunrise and ends with sunset. Lead them to understand that sunrise *causes* daylight. Help them see that when the sun sets, it causes daylight to cease, so night comes.

*Ask children why mother wants them home when the evening is over. Where is the sun? So, what will it be like outside?*

**For Better Understanding**

The foregoing sub-concepts have emphasized that the sun rises in the same *general* direction each morning. But it does not rise in *precisely* the same direction. On 21 March the sun rises exactly in the east. After that, it rises more and more to the north of east each day until 21 June, which is also the longest day of the year. Then the sunrise position moves back again until it is exactly east on 22 September. After this date, the sun rises at a point more and more south of the east until 22 December, when it is as far toward the southeast as it can go. Then the sunrise position gradually moves back until it reaches east again on 21 March

In a similar way, the sun sets exactly in the west on 21 March and on 22 September. During the spring and summer months, when the sun rises north of east, it sets north of west. During the autumn and winter months when the sun rises south of east, it sets south of west. These details of sunrise and sunset are certainly not appropriate for children at class I level. However, it is useful for the teacher to know about them so that he can interpret children's observations correctly. The teacher and the children should not be concerned when they find that the sun usually rises not 'exactly in the east'. It is enough for them to know it rises 'in the eastern part of the sky'.

The times of sunrise and sunset vary during the year and also from place to place throughout this country and the world. On 21 March and on 22 September, sunrise and sunset are 12 hours apart—anywhere in the world. After 22 December, throughout India the sun rises a little earlier and sets a little later every day until 21 June, the longest day of the year. Then the days get shorter again until 22 December, the shortest day of the year. However, the exact time of sunrise and sunset is different in different parts of the country. On a day when the sun rises in Calcutta at 0530, it is still dark in Bombay, far to the west. On this day, the sun does not rise in Bombay until about 0630.

Again, the details of these variations are too much for class I children. However, they can be invited to remember how the day begins very early in the summer, usually before they get up. Yet in the winter, the sun rises later, and children sometimes get up while it is still dark.

**Scientists at Work**

**Ancient people used the sun and the stars to tell time**

Most of you—most children of your age—do not have a watch of your own. When you want to know what time it is, you ask your parents or you ask someone who has a watch. But what do you do if you cannot find someone who has a watch? Then all you can do is to guess what time it is.

Suppose you lived without a watch for many years. And suppose none of your friends had watches either. Do you think you could learn to guess pretty well what the time is even without a watch? There are some people even today who never use a watch. They have learned to guess what time it is quite well without a watch or a clock.

What about the ancient people of long ago? What did they use to tell time? Watches and clocks were invented only a few hundred years ago. But there were well-developed farms and villages and cities in our country more than five thousand years ago. How did our ancestors tell time?

People have for thousands of years been telling time without the aid of clocks and watches. Do you know what they used to help them guess what time it was? They used something you know very well—something you see almost every day. They learned to tell time with the aid of the sun. These ancient people used sunrise to mark the beginning of the day. The end of the day was when the sun set. For them the middle of the day—noontime—was when the sun was as high in the sky as possible that day (see Fig. 1-2). Up until noontime, the sun climbed higher and higher in the sky. After noontime the sun settled lower and lower towards the western horizon.

Then how did these people tell what time it was at night? For an hour or so after sunset they could still see some glow in the western sky, so they knew the night was still young. Likewise, when the first glow of light appeared in the eastern sky after the hours of darkness, they knew that morning was coming soon. During the hours of total darkness, these early people even learned to tell time by the stars. But that is another story. You do not yet know enough about the positions and the movements of the stars to use them for telling time.

Fig. 1-2
People of long ago learnt that the sun was high in the sky at the middle of the day.

However, you can learn to use the sun as a guide in estimating what time it is. Learn to study the position of the sun when you are out of doors. Where is the sun when you go to school, when you have your lunch, when you return from school? In the morning do you get up before sunrise or does the sun rise before you do? Is this true during all months of the year?

Learn to watch the position of the sun. With practice, you can learn much about using it to help tell time. Of course, this method is not so accurate nor so convenient as a watch. But the sun is free—and you don't have to wind it!

## 3. THE APPEARANCE OF THE MOON CHANGES FROM DAY TO DAY

All adults are aware of the cycle of changes in the apparent size and shape of the moon. Most adults understand the reason for the changes. Small children, however, need help in seeing this pattern of lunar changes for themselves. Often they think that the moon *actually* changes its shape, whereas adults know that it only *appears* to change. In this sub-concept no attempt is made to have children understand *why* the moon's appearance changes. Also no attempt is made to teach children the nature of the lunar cycle, nor the changes in the time of the moon's rising and setting. Rather, children are merely helped to see *for themselves* that the moon appears to change its shape from night to night. They are also helped to notice other changes in the moon's appearance, changes such as those in size and colour.

### 3(a). THE MOON APPEARS ROUND ON SOME NIGHTS, PARTLY ROUND ON OTHERS

The moon appears in a variety of shapes. On some nights it is perfectly round; this is called 'full moon'. Sometimes the moon appears as a half circle, more often the moon looks like a lop-sided ball or like a crescent in the sky. Children can be helped to see this for themselves through activities such as these.

**Field Observation**

**What is the appearance of the moon?**

Encourage children to see with the aid of their parents what the shape of the moon is on a given evening. Ask children to report their observations next day by means of a simple sketch. When there has been an agreement of all observers on how the moon looked, record this on a chart. Repeat this for as long as children remain interested. On the chart, show the series of sketches of the moon's appearance night after night. Help children describe the moon's appearance in terms like 'full moon', 'nearly a circle', 'half circle', and 'crescent'.

*If there are enough observations in the chart made in the previous activity, draw children's attention to the gradual growth of the moon's size from crescent towards full.*

When the moon is precisely full, it rises in the east at almost the same time that the sun sets in the west.This makes a very convenient observation for young children. Each night the moon rises almost fifty minutes later than it did the previous night. Children can note this for themselves, and can observe the moon as it begins to wane (grow smaller from the condition of full moon) through activities such as these.

**Field Observation**

**What is the moon's shape just after full moon?**

Encourage children to observe for themselves the shape of the moon during the few nights immediately after full moon. Ask them to make a sketch of the moon's appearance. Keep a chart of the moon's appearance for as many days after full moon as the lateness of the hour permits. Help children realize that they are seeing a gradual change in the moon's shape as it grows older after being 'full moon'.

*In connection with the above observations, have children note the time of the rising of the waning moon. This is about fifty minutes later each successive night.*

*On certain feast-days and festivals, children keep awake late in the night. Utilize this fact to encourage them to do their observations on these occasions, and report the same in the class. Let them pool up their observations and discuss.*

Encourage children to observe the colour of the moon. When it is high in the sky it appears white. But when it is close to the horizon it appears yellow, orange or red. Invite them to make coloured drawings of its appearance. Ask children if the full moon always appears of the same size. It looks larger when near the horizon. Discuss with them whether it is *really* larger or simply *appears* larger. (The latter is the case).

**3 (b).** ON SOME NIGHTS THE MOON CANNOT BE SEEN

There are a few nights each month when the moon cannot be seen at all, even if the sky is clear. This happens when the moon is in nearly the same direction as the sun. Then the sun's intense light makes it impossible to see the very thin crescent moon.

There are dates marked on the calendar as 'new moon'. Strictly speaking, this situation might better be called 'no moon', for on that night the moon is nowhere to be seen. To make an observation of 'no moon', then, it is necessary for one to try to find it and be unsuccessful. Children can be helped to make this observation in this manner.

**Field Observation**

**Are there times when the moon cannot be seen?**

Consult a calendar and find the date of the month indicated as 'new moon'. On this night, challenge children to observe the appearance of the moon. Encourage them to get whatever help they can from their parents or other adults. When the following day they report their failure to find the moon, introduce them to the concept of 'no moon'. Help them realize, however, that the moon is not really 'gone'. Rather, it is invisible simply because it is in nearly the same direction as the bright sun.

*A day or two after 'no moon' ('new moon' on the calendar) invite children to look at the early evening sky for the thin sliver of the slender crescent moon. Point out that the moon's direction is slowly swinging away from that of the sun and so it can now be seen.*

**For Better Understanding**

The cycle of the moon's changes requires approximately 29-1/2 days. Throughout this cycle, the moon grows from no appearance at all through a crescent, to the appearance of a half circle, to that of nearly a circle, to full moon. The shape of the moon seems to grow or *wax* from nothing to full moon. The appearance of the moon seems to be made more or less from the right-hand side of a disc. After full moon, the moon's shape grows smaller or *wanes*. This time the appearance of the moon seems to be made more or less from the left side of the moon's full disc.

Although class I children are too young to comprehend it, it is important for the teachers to realize that the moon's change in appearance is due to a change in illumination by the sun. The moon is a sphere, slightly more than one quarter the diameter of the earth, and almost 400,000 kilometres from the earth. As the moon swings around the earth and the earth swings around the sun, the relative positions of these three objects change. As a result, the moon—as seen from the earth—is illuminated from different directions. At full moon, the sun is directly behind the observer's back, so the illuminated half of the moon is towards him. At other times, only part of the moon's illuminated half is towards the observer. As a result, he sees only a portion of the moon.

The apparent shape of the moon is called its *phase*. Fig. 1-3 shows the common phases of the moon along with the name given to each, and the time in the lunar month when it appears.

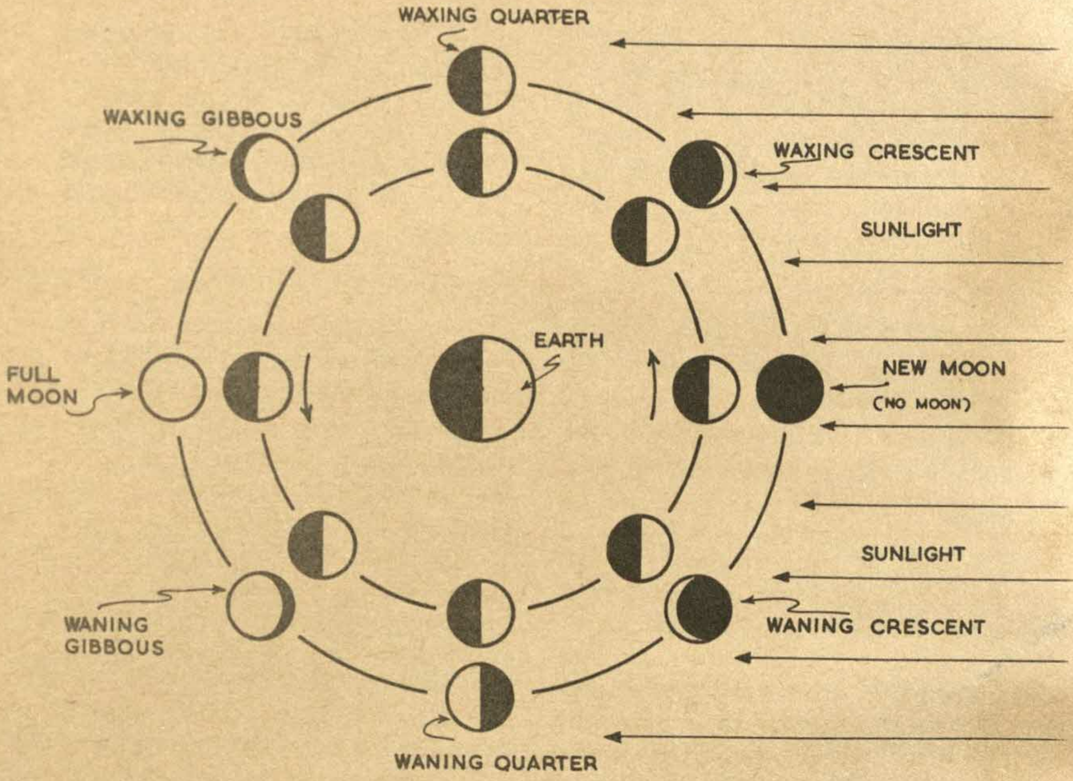


Fig. 1-3
The outer circle shows the eight principal phases of the moon as seen from the earth. The inner circle suggests how the sun, shining from the right, produces these phases. The numbers below each phase indicate how far along the lunar month is, starting from new moon (no moon).

# UNIT 1

# OUR UNIVERSE

# CLASS II

## Overview

Knowledge of the sky for class II students continues to be based largely on first-hand observation. Although the teacher gives students much of their knowledge through 'telling', he encourages students' own observations as much as possible. They can review the knowledge they acquired in class I and can add more and more to it.

Here in class II, children already know where the sun rises and sets, and that it is the producer of daylight. Now they can begin to learn more about the sun, such as a rough idea of how big it is, and how far it is from the earth. They also make some first-hand observations concerning the heating effect of the sun. In addition, they find out about shadows that they are not simply 'dark things', but are places where direct sunlight does not fall. They learn that a shadow is not produced simply by an object, but also by the sun or other sources of light which shine on the area around a shadow.

Again, the 'big ideas' of *variety* and *change* are found throughout this unit at this class level. The heat and light given by the sun seem to change. The sun is more intense in mid-day, less so in the first few hours of the morning and the last few hours of the evening. Shadows in particular are highly changeable things. They change in size and in shape and in how dark they are. These changes are directly related to changes in the apparent position of the sun.

Children in class II are interested in sky science. They are fond of looking at objects in the sky and wondering how they got there, and why they behave as they do. This simple curiosity is a trait of mind to be encouraged in young children. They should be helped to satisfy this curiosity by observation whenever possible. They should begin to realize that observation is a most important tool in learning science, and that they—class II children—are perfectly capable of making useful observations of their own.

### 1. THE SUN LIGHTS AND WARMS THE EARTH

Children have already learned about day and night. They know it is the sun which gives the earth light. But if one sits in sunlight, he also experiences some warmth. This shows that the sun gives the earth warmth along with light; children know this because they have experienced it. They themselves like to bask in the sun when the weather is cold.

So do adults.

### 1(a). DAYS ARE BRIGHT AND NIGHTS ARE DARK

One is not required to fumble or grope for his way during the day. He can see because there is light during the day. Movement is difficult at night. Things cannot be seen as it is dark and so there is no light by which objects can be seen. That the days are bright and nights are dark is something of common observation for all. This fact can be further stressed by making an appeal to children s own observations and also by means of simple experiments. Here are some suggestions.

**Investigation**

**What is darkness?**

Pose a question before children: Why is a torch or a lantern not necessary in the day? But why is it so necessary at night? Ask a child in a lighted room to bring some thing from a shelf or table and hand it over to you Arrange to darken the room so that night conditions are created and repeat your instruction. Let children notice the difference and give the reason why it is difficult to carry out the instruction in the dark. Help them realize that darkness is not 'something added', but is instead something (light) taken away. Discuss the investigation not in terms of 'we can't see because it is dark', but rather in terms of 'we cannot see because there is too little light.' Help children realize the essential role of light in making vision possible.

*Discuss with children such questions as: When you wake up early, how do you know whether it's night or morning?*

*Why are cars, cycles, and trains equipped with lights for night use? Why do farmers hang a light under their bullock carts at night?*

**For Better Understanding**

Children often regard darkness as something *real* and tangible; sometimes they are afraid of darkness. Adults sometimes use phrases such as 'push back the darkness', or 'so dark you can feel it'. Actually, of course, darkness is simply the absence of light. It is important for teachers to realize this, and to help children begin to approach this understanding.

### 1 (b). DAYS ARE WARM AND NIGHTS ARE COOL

Children and adults have experienced temperatures by day and by night. Sometimes even during winter, it is not necessary to wear a sweater during the day-time. But at night, when one has to go out, one usually puts on a sweater or some warm clothes. When in bed, some woollen blanket is necessary in winter. If one is sleeping outdoors, one may need some cover late in the night even when it is summer.

In summer, farmers work mostly bare-bodied in the day and put on some light clothing only at nightfall. Here are some activities which will enable children better to understand the relationship between daylight and warmth.

**Familiar Experience**

**What is the warmest part of the day or night?**

On a rather cold day, ask children where they would prefer to have their class—in the classroom or out in the sun. Start a discussion as to why they prefer to be in the sun when it is cold. Draw on their own experience to realize that it is warmer in the sun. This will help children understand that the sun not only gives light, but also heat. Because the sun shines only in the daytime its warmth is available only during day and not at night. This means that days are warmer than nights.

*Draw children's attention to situations like these: farmers as well as their animals take shelter under a tree during the middle of the day. When they have to keep a nightwatch, they wrap themselves in woollen blankets. Often they kindle night fires.*

### For Better Understanding

Often early nights are warmer than mornings. This is particularly true in areas which are far inland or in valleys. In a tropical country like ours, the earth is greatly heated by the blazing sun. Throughout the early night much of this heat is retained by the earth and the lower atmosphere. This makes the early night quite warm. After the earth has cooled during the night, it takes some time for the earth to get heated after sunrise. As a result, the early morning is cooler than early night. However, by and large, the day is warm and the night is cool.

Many people have the idea that the sun's light and the sun's heat are really the same thing. This is not true. The sun provides light which permits vision. The sun also provides radiant heat. It is difficult at the primary school level to separate the sun's light from its heat for demonstration purposes. However, the teacher should encourage children to think of 'sunshine' as including visible light and radiant heat, among other things. Actually, 'sunshine', also contains radio waves, ultra-violet radiation, and many other forms of energy in addition to light and heat.

There is another basic principle involved in understanding daylight and darkness. Although it need not be brought specifically to children's attention, the teacher should be aware of it. Nearly everything one sees is made visible by reflected light. It is true that electric lamps and kerosene lamps and candles and fires give off their own light. So does the sun and so do the other stars. But most common objects are visible because the light from the sun or a lamp shines directly or indirectly upon them. If there is no light shining on them, they cannot be seen, since they give off no light of their own. Therefore, when the sun is gone at night, ordinary objects are invisible unless there is some other source of light to illuminate them.

## 2. THE SUN IS A VERY LARGE, HOT BALL

The setting sun is like a big, red ball. Children have seen it. Their observation gives them some idea as to the shape of the sun. The sun is round. But there is a third dimension. The sun is not a flat round disc, but a ball or a sphere. When viewed from a considerable distance, a spherical object gives the appearance of being flat. So although the sun appears like a circular disc, it is in reality a sphere.

The sun gives the earth warmth even though it is far away. So the sun itself must be hot. When one moves away from a source of heat, one experiences less warmth. Children have certainly noticed this. Therefore, it is natural for them to see that if it can get very hot on the earth in spite of the sun's distance, the sun itself must be extremely hot.

### 2(a). THE SUN'S SURFACE CONSISTS OF HOT, GLOWING GASES

Burning coals are visible because they glow. Even in the dark, it is easy to tell when a person is smoking a cigarette. The cigarette end glows. These illustrations are from children's experience, so they can easily appreciate that the sun is a hot glowing body. Now it is necessary to show them that the sun's surface is not solid, but consists of gases. Evidence for this can be provided by simple experiments. A group of such experiments is suggested below.

**Investigation**

**What makes us think the sun's surface is a gas?**

*Materials required*
thin metal wire,
wood stick,
paraffin,
source of heat
(flame)

Obtain a fairly thin metal wire. Fit its one end into a stick of wood as a handle. Allow a child to heat the wire on a spirit lamp or stove or any convenient source of heat. Let the heated end become red. Now remove it from the flame. Let the class observe how it glows. Let the wire be heated until it becomes white hot. Ask the child to take it quickly to a dark corner close by. Let the children see how it gives off light. This relates to what they have already learned about the sun being very hot and therefore giving the earth both heat and light.

Now obtain some paraffin or candle wax. Put it in a dish and ask a child to heat it. It melts. Children will get some idea that under conditions of heat it is difficult for objects to remain in a solid state. Ask them what happens to butter when heated. Now let the melted wax be further heated. It vaporizes; children can smell the vapour. Children will realize that under conditions of extreme heat things do not remain as liquids. Remind them that water changes into gas when it is heated. Help children to the conclusion that any material will become a gas if it gets hot enough. Let them thus learn and appreciate that as the sun is very very hot, things cannot exist there as solids or liquids, so the sun must have hot glowing gases. See Fig. 1-4.

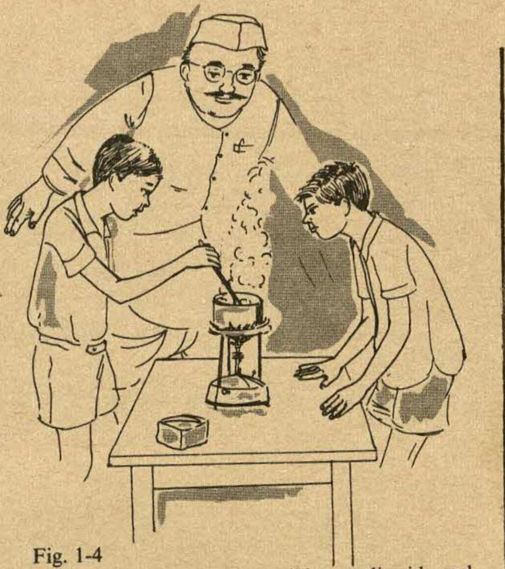


Fig. 1-4
Paraffin changes from a solid to a liquid, and then to a gas.

*Heat sulphur in a crucible and let children see the changes of state and learn that at very high temperature, materials do not remain solid.*

*Organize a visit to the village blacksmith shop and goldsmith shop. See how high temperatures can melt metals.*

**For Better Understanding**

The temperature of the sun is extremely high. Near the surface it is about six thousand degrees Celsius (centigrade). Deep inside the sun the temperature is many millions of degrees. This should be understood in relation to everyday temperatures. The temperature of human body normally is 37°C and that of boiling water 100° C. Surely the temperatures of the sun stretch the imagination.

The hot gases at the surface of the sun are extremely rarefied; they are much less dense than the earth's atmosphere. At deeper and deeper layers of the sun, however, the pressure increases. In the central part of the sun's sphere, the pressure is enormous. Here, although the temperature is many millions of degrees, the pressure is so great that the materials cannot exist as ordinary gases. It is an extremely hot material under extremely great pressure. As a result, it behaves unlike any material known on earth. Thus, it is not correct to think of the sun as a giant ball of hot gas. Only the outer layers can be properly described as gas.

Children and adults often think of the sun as a giant ball of *fire*. Actually, the sun is not *burning* in the familiar sense of the word. Its source of energy is more like that of a nuclear reactor than it is like a flaming furnace. Children will learn more about this in future class levels.

### 2(b). THE SUN IS ENORMOUS, IT APPEARS SMALL BECAUSE OF ITS GREAT DISTANCE FROM THE EARTH

Actually the sun is much larger than the earth and the moon is much smaller. Yet the sun's disc and the lunar disc appear to people on the earth as nearly of the same size. This is because while the moon is less than 400,000 kilometres from the earth, the sun is nearly 150,000,000 kilometres away. If one goes up on the terrace or roof of a tall building or on the top of a hill and looks at things down below on the ground, the things appear to be very small. The greater the distance from which the observer looks, the smaller the objects appear to be. Simple observations like those suggested here will illustrate this.

**Field Observation**

**Why does the distant sun appear about the same size as the much nearer moon?**

Take children up on the terrace or roof of a building or if possible on a hill top. Let them see how things on the ground level appear. Let them compare what they see from this great distance to what they see when they are close to the objects. Take them to the playground. Ask them to look at a rather distant tall object like a lamp post of a house. Let them close one eye and hold a finger before the other eye and move it to and from till the object is just hidden from sight, as in Fig. 1-5a. Let some child measure the distance between the finger and the eye. Now let the group approach the tall object and let the same child repeat what he did. By holding the finger at the same

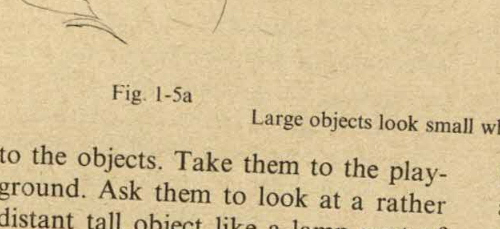


Fig. 1-5a

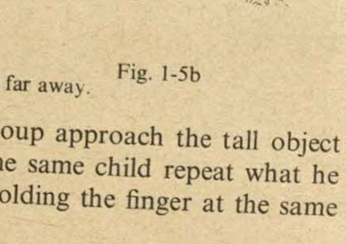


Fig. 1-5b

Large objects look small when they are far away.

distance can he shut off the object from sight? Let the children now discuss why he could not do so. Help them understand that in the second case the tall object appeared larger because it was nearer.

**Investigation**

**How can a small ball and a large ball be made to appear the same size?**

*Materials required*
large ball or round earthen jug,
small ball or marble or round wad of clay,
two straight edged pieces of wood or paper

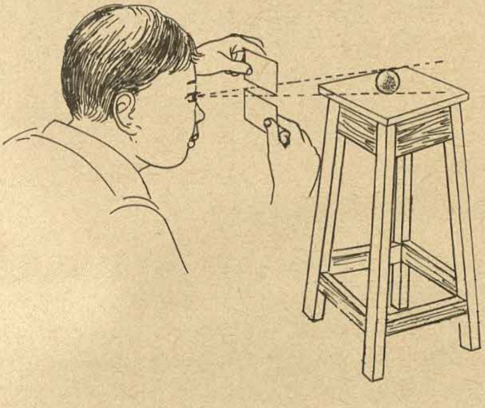


Fig. 1-6a

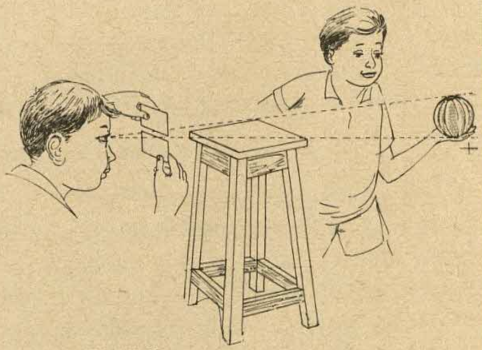


Fig. 1-6b

A small nearby object may appear to have the same size as a large remote object.

Place a small ball so that a student can see it between the edges of two pieces of wood or paper, as in Fig. 1-6a. The edges should be so adjusted that the small ball is just barely visible between them. Now have another child move a large ball or round earthen jug farther away from the observer. It should be so placed that this too can barely be seen between the two straight edges. Help the students realize that the two round objects appear to be the same size to the observer, even though one is much larger than the other. Help them see that in a similar way, the sun appears the same size as the moon, even though the sun is much farther away than the moon.

*Call attention to the fact that the rails of a railroad track seem closer when they are farther away. The same is true of electric wires suspended from poles.*

*Have a child mount a round coin on a stick and adjust it so that it just barely 'eclipses' the setting sun. Does the same coin at the same distance just barely 'eclipse' the moon also?*

**For Better Understanding**

The sun, at a distance of about 150,000,000 kilometres, is roughly 400 times as far away as the moon, which is less than 400,000 kilometres away. The sun has a diameter of some 1,400,000 kilometres. The moon's diameter is roughly 3,400 kilometres. The ratio of sun's diameter to moon's diameter is also about 400 to 1. There seems to be no reason *why* this should be true—it just happens to be that way. However, it is because the sun is about 400 times bigger than the moon, and also about 400 times as far away that the sun appears to be almost exactly the same size as the moon. This general idea is shown in Fig. 1-7.

## 3. WHEN LIGHT IS OBSTRUCTED SHADOWS ARE FORMED

When doors and windows are closed, one cannot read very well. The doors of cinema theatres are heavily curtained so that no light enters. This shows that when an opaque thing comes in the way of light, light is cut off and objects on the other side of the opaque thing do not receive light. They are in the *shade* or in the *shadow*. At midday, persons and animals take shelter under a tree or by the side of a wall where there is a shadow. People often speak of 'being in a shadow', or of 'casting a shadow'. Perhaps for this reason, children often think of a shadow as a real thing—something which can be felt and perhaps even weighed. They should be helped to realize that a shadow is merely a pattern of reduced light, and that the shadow is caused by some opaque (non-transparent) material which blocks the light.

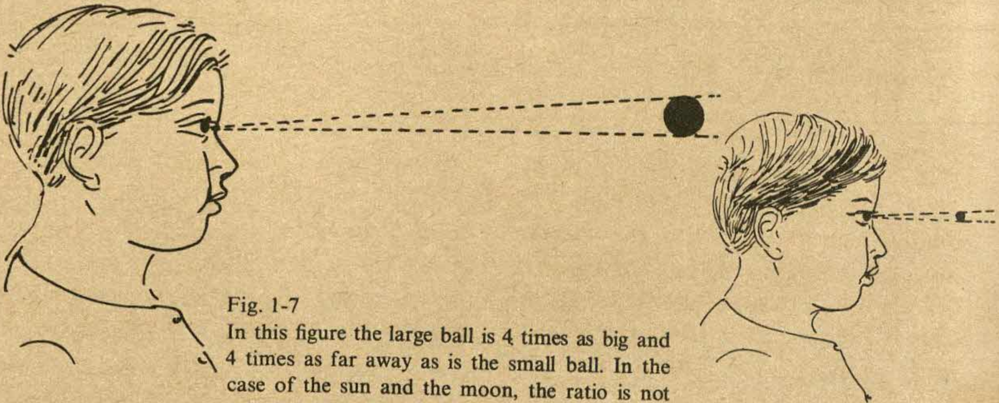


Fig. 1-7
In this figure the large ball is 4 times as big and 4 times as far away as is the small ball. In the case of the sun and the moon, the ratio is not 4:1; it is about 400:1

### 3(a). WHEN LIGHT IS OBSTRUCTED SHADOWS ARE CAST

If a piece of card-board is held in front of a lamp or some source of light, its shadow is cast on the ground or on the wall or on both. This is because the card-board, which is opaque, blocks light. The same thing happens when an opaque object obstructs the rays of light from the sun. So, no matter what the source of light may be, when opaque objects obstruct light, shadows are cast.

Clouds also cast shadows on the ground. On a very hot day a farmer can tell when a cloud's shadow falls upon him without even looking at the cloud; he can tell that there is reduced light and heat as long as he is in the cloud's shadow. On a bright day people often hold their hand in such a way as to produce a shadow on their eyes, so things do not look so bright. Here are some activities which will help children become more familiar with the presence of shadows and with their causes.

**Field Observation**

**What are the conditions within a shadow?**

On a very hot day, take children outside, or let them observe from the protection of a school room window. Ask them where they would prefer to be when it is so hot. Without hesitation they will indicate that they prefer some place where it is shady. Discuss with them why they prefer the shade. Help them realize that in a shadow they are protected from the direct rays of the sun—both light rays and heat radiation. Ask them what produces the shadow they see. Help them realize that every shadow is produced by an opaque object.

**Discussion**

**What causes shadows?**

Involve students in a discussion of what produces shadows. Ask them if a shadow can be felt with the fingers (not for temperature, but for touch). Ask them if a shadow can be weighed. Can it be separated from the object which casts it? Ask them if there are shadows at night? Would there be shadows on a very dark night when there were no lights whatever? Help them realize that a shadow is not a material *object*. Rather, it is a *condition* of reduced light from some source of light.

**Familiar Experience**

**What determines the shape of a shadow?**

Draw the attention of children to the game 'light-and-shadow' that they often play in sunlight. Now ask who casts the shadows. Let them move out in sunlight. Encourage them to observe their own shadows and find out that they themselves cast these shadows and so do many other objects. Let them discuss and determine whether shadows are possible in the absence of light. Let them do simple classroom experiments using different sources of light like an oil lamp, a candle and a torch. They can find out that whenever an opaque object cuts off light, its shadow is cast on the side away from the source of light.

*Organize a game of 'shadow tag', where a person is 'safe' as long as he is in a shadow. Can 'shadow tag' be played on a cloudy day?*

### 3(b). OBJECTS CAST THEIR SHADOWS

It is not difficult to help children realize that opaque objects cast shadows. Frequently, however, the shape of a shadow is very different from that of the opaque object which produces it. It is possible to help children realize that there is a very close relationship between the shape of a shadow-producing object and the shape of the shadow. Indeed, children can be helped to an excellent example of cause-and-effect relationships, where the source of light and the opaque object are the cause and the shadow is the effect. Here are some activities to help do this.

**Investigation**

**What is the shape of a shadow produced by an object?**

*Materials required*
bright light source, paper, scissors

Arrange a source of bright light, such as lamp, bulb or a petromax lantern, so that it casts shadows on a wall of the classroom. Hold up familiar objects and challenge students to identify them by their shadows, as in Fig. 1-8. How does the shape of the shadow change as the paper shapes are twisted? See if students can recognize their classmates only by their shadows.

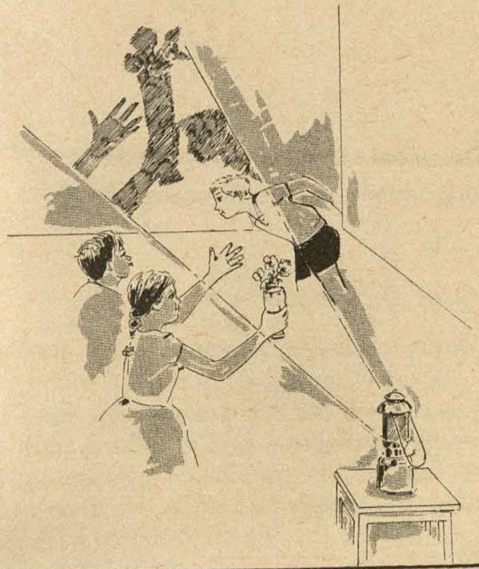


Fig. 1-8
The shape of a shadow is determined by the shape of the object which produces it.

**Investigation**

### How do opaque objects produce distinct images?

*Materials required*
bright light source,
glass tumbler, brick
or wood block, string
or thread

Support a brick or a block of wood on a glass tumbler. Arrange a bright light source so that it casts a clear image of the block on the wall. Note carefully the positions of the *corners* of the shadow. Now stretch a string from the light source to a corner of a shadow, as in Fig. 1-9. Does the light seem to go in a straight line from the source past the corner of the shadow? Help children realize that a tightly stretched string forms a straight line. Help them understand that the cause-and-effect relationships in shadow formation exist because light travels in a straight line.

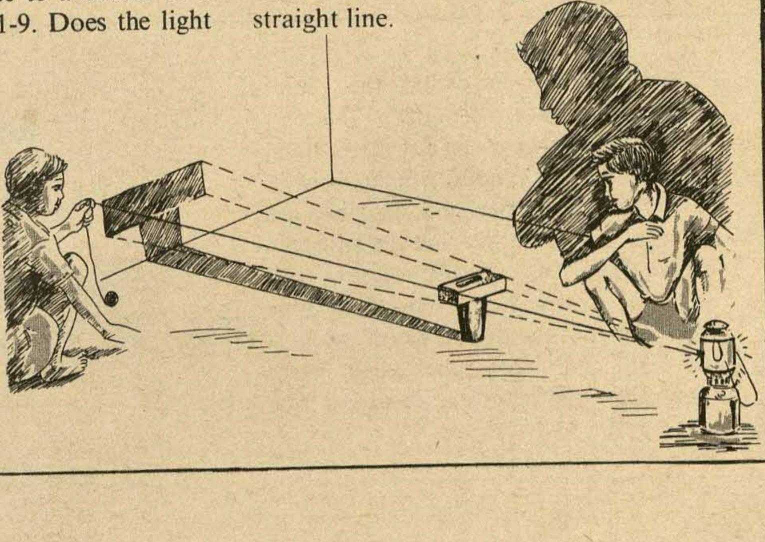


Fig. 1-9
Objects cast shadows because light travels in straight lines.

*Invite children to produce shadow figures of people, animals, and familiar objects using their hands between a light source and a wall.*

## 4. SHADOWS CHANGE IN LENGTH AND DIRECTION

Shadows cast in the morning are long. They are long again in the evening. When the sun is directly overhead, the shadows are directly under the objects. In the morning the shadows fall westward from the objects which produce them. In the evening they fall eastward. From this it is clear that the direction in which shadows are cast is opposite to the source of light. Thus shadows change in length and direction, depending on the relative positions of the object and the source of light. This change in length and direction of shadows is a matter of day-to-day experience for all. At night, when lamps are used as sources of light, the same things are noticed.

### 4(a). SHADOWS ARE LONGER IN THE MORNING AND IN THE LATE AFTERNOON THAN AT MID-DAY

In the morning and in the late afternoon, the rays of the sun are slanting and as a result the shadows cast by objects are long. At mid-day the rays shine down on objects almost vertically and so the shadows come nearly under the objects. Children have seen these things. They can do experiments using a suitable source of light and holding it in different positions in relation to the object. They can learn that the relative position of the surface on which the shadow falls is responsible for the changes in length of shadows at different times of the day. Simple activities of the type indicated below will help children to learn about these things.

**Field Observation**

**What determines the length of a shadow?**

Let children tell what they have observed about the lengths of shadows at different times of the day. Take them out several times and help them observe. Let them tell when the shadows are longest and when they are the shortest. Have them also notice the position of the sun in the sky. Help them thus discover that the way in which the rays of light fall upon the earth helps determine the length of shadows. See Figs. 1-10a and 1-10b.

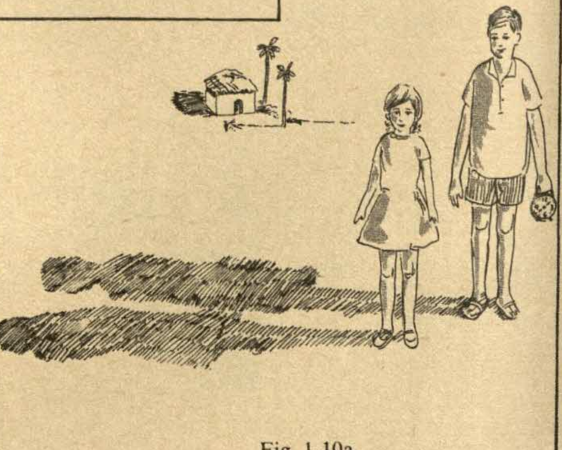


Fig. 1-10a

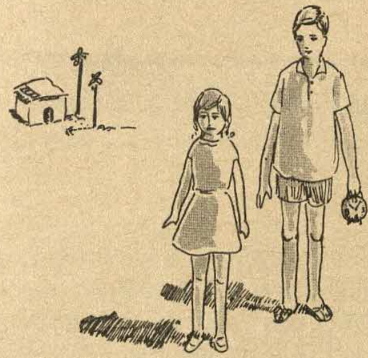


Fig. 1-10b
The angle of the sun's rays helps to determine the length of shadows cast on the ground.

**Investigation**

## Why do shadow lengths vary with the position of the sun?

*Materials required*
bright light source,
straight stick,
clay or other support
for stick

In a somewhat darkened classroom, place a brick on its end on the floor. Use a torch or petromax to produce shadows of this brick. Start with the torch low and to the east of the brick (as the morning sun). Note the direction and length of the shadow (see Fig. 1-11a). Raise the torch to a position nearly straight above the brick and again note the shadow. What is the length of the shadow when the light source is taken near the floor and to the west of the brick? Help children see the resemblance between this model and the real sun as it casts shadows of a vertical pole throughout the day.

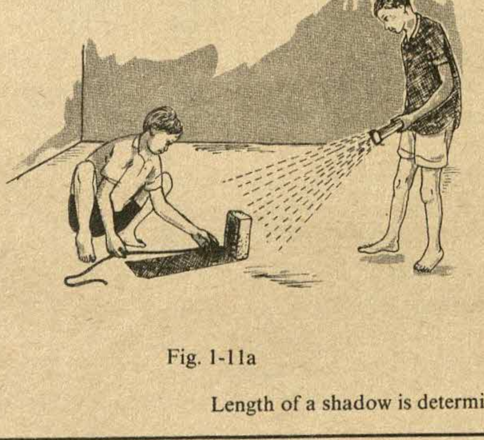


Fig. 1-11a

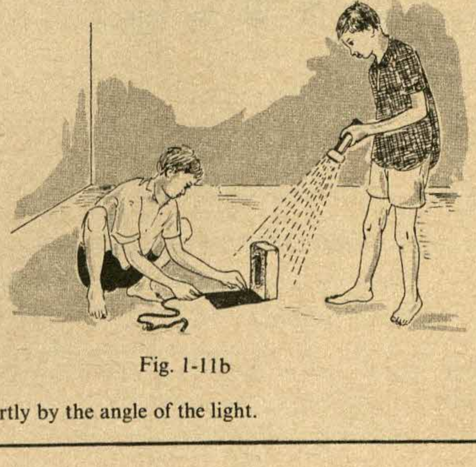


Fig. 1-11b

Length of a shadow is determined partly by the angle of the light.

*Organize a contest to see who can cast the longest shadow of himself. Some children will cast their shadows on walls. Others may cast shadow early in the morning or late in the evening in order to make long shadows.*

### 4(b). SHADOWS OF AN OBJECT ARE IN A DIRECTION OPPOSITE TO THE SOURCE OF LIGHT

Like the previous sub-concept, this one is a matter of daily observation for children and adults. The very nature of shadow formation demands that the opaque object be between the light source and the shadow. Hence, the shadow is always on the opposite side from the opaque object as compared to the light source. Activities to make this point clear can be arranged something like those in Fig 1-10 and Fig 1-11. However, the emphasis should be not on the *length* of the shadow, but on *direction* in which it is cast. Here also are some other activities to help make these ideas clear to children.

| **Investigation** | **In which direction will a shadow be formed?** | *Materials required*<br>bright light source |
|---|---|---|

Set up a torch or similar source of bright light so as to produce a shadow of an opaque object, *but do not turn on the light*. Challenge children to predict where the shadow will be formed, as in Fig. 1-12. See who can make the most accurate prediction. Now turn on the light to evaluate the predictions.

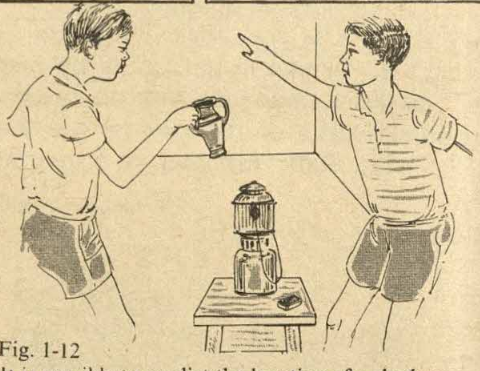


Fig. 1-12
It is possible to predict the location of a shadow.

*When playing outside, ask several children to run towards their shadows. Do they all run the same way? How does the direction of their running compare with the direction of the sun?*

# UNIT 1

INSTITUTE OF EDUCATION FOR WOMEN ★ CALCUTTA-27 ★
Dept. of Extension
SERVICE.

# OUR UNIVERSE

## CLASS III

### Overview

Learning in classes I and II has been largely confined to observations and telling by the teacher about what is to be seen in the sky, and what changes occur there. Beginning now with class III, however, children take another kind of step in their understanding of sky science. From here on they begin to learn about *why* the objects in the sky behave as they do. That is, they are giving attention to the cause-and-effect features of natural events. They are beginning to learn that the events of nature do not *simply happen—all by themselves*. Rather, effects occur because there are causes.

In this unit, class III children begin to learn about the cause of day and night. Prior to this class they have observed this phenomenon; now they will learn that day and night result from the fact that a round earth is spinning on its axis. Similarly, they begin to learn about time and its relation to the rotation of the earth. Once more they consider their observation of the changes in the appearance of the moon. Throughout this series of learnings children continue to make observations. Now, however, some of these are deliberately arranged in the classroom. These observations begin to take on the character of experiments, rather than mere passive observations of nature.

At this class level, children are still concerned with the changes that take place in the sky. But now they begin to see *patterns* in these changes. This is not only in the simple case of day and night, but in the more complex one of the phases of the moon.

Thus at this class level, mere observation is supplemented by experimentation. Also the observation of natural events is supplemented by a consideration of the causes of these effects. Changes are still important subjects of learning, but attention is now directed towards the pattern in which such changes so often occur. The child is becoming more mature, and his approach to the learning of science matures accordingly.

### 1. THE EARTH IS A BIG ROUND BALL

As a result of investigation and thought given to the problem for thousands of years, it is now accepted that the earth is really round. Photographs of earth taken from space ships indicate that the earth is round; observations of incoming and outgoing ships

**Field Observation**

### What is the shape of an eclipse of the moon?

Whenever there is a lunar eclipse, encourage children to watch it and report to the class the shape of the eclipsed portion. Tell them that an eclipse is caused because of earth's shadow on the moon. Let them now infer the shape of the earth from the observation that its shadow on the moon is round. They have already learnt that the shape of a shadow resembles that of the object which casts it.

**Scientists at Work**

### Early scholars develop the idea of a round earth

Almost everyone in the entire world who stops to think about it agrees that the earth is round—like a ball. You believe this too. But why do you believe it? Do you believe it just because your parents or your teachers have told you so. Do you have any first-hand evidence that the earth is round? After all, it looks very flat indeed. Of course, modern photographs taken by astronauts clearly show that the earth is like a ball. But when did early scientists first get real proof that the earth is round?

One of the first kinds of real evidence of the roundness of the earth came when the first man sailed a ship around the earth. This was a Portuguese navigator named Magellan. He was sailing in the service of the King of Spain. He undertook to approach some islands in what is now Malaysia by sailing westward to where he thought they were. In 1519 he started with five ships and crossed the Atlantic Ocean to South America. The seas were very rough when he passed the southern tip of South America. As he entered the next ocean, he found it very calm and peaceful, so he called it the Pacific Ocean.

It took Magellan more than three months to sail across the Pacific Ocean. Magallen himself was killed in the Philippine Islands. However, nineteen men and one of the ships finally returned to Spain. They had taken three years to go around the world. Surely this was actual proof that the world was round.

Of course, Magellan believed the world was round before he started on his long voyage. So did Columbus, the Italian navigator who sailed across the Atlantic Ocean to North America in 1492. Columbus was trying to find the wealth of the Orient—the East Indies—by sailing westward. He did not know that the two American continents existed. When he first sighted land, an island near North America, he thought he had found the East

Indies. And he called the natives he saw there Indians.

Marco Polo was another of the great early explorers. He was an Italian boy who at the age of fifteen started on a long adventure with his father and his uncle. After many false starts and long, difficult journeys, he finally arrived at the court of Kublai Khan in 1275, when he was 21 years old. Kublai Khan's court was a few hundred kilometres north west of what is now Peking. He remained in the service of the great Mongol Emporer for 17 years, and travelled throughout the far east, including at least one trip to Indonesia. When he finally returned to Itlay he wrote his famous account, "The Book of Marco Polo". It was filled with such unusual stories that most people did not believe it. Marco Polo probably believed the earth was round, although he certainly did not prove that this was so.

Even before the days of Marco Polo the conquering hordes of Genghis Khan travelled great distances. Some of them actually went a quarter of the way around the world, although they may not have realized it. During these times the Vikings of Norway and Iceland also covered great distances. It is now known that they attempted to set up colonies in Greenland, and that some of them went well into what is now Canada and the United States. Although they did not know it, these early explorers reached a point about half way between the Atlantic and Pacific Coasts of the United States.

But long before this—well over 2000 years ago, in fact, ancient scholars believed in a round earth. True, they had seen ships gradually disappearing over the horizon as they left port; first the hull of the ship would disappear, and the tops of the masts were the last things to be seen. But the most direct evidence of all came from Greek mathematicians, and they did not have to travel very far to get it. It was known that on a June day, the sun was directly over head in a certain city in Egypt. Yet at the same time, the sun was not over head in Greece, several hundred kilometres to the north. In Egypt the sun shone directly into a deep well, as shown in Fig. 1-15. But farther north at the same time, the sun did not do this. Eratosthenes of Greece thought he could explain this by assuming the earth to be round. On this assumption, he measured the angle of June mid-day sunlight in Greece and calculated the size of the earth. According to him, the earth was between 10,000 and 12,000 kilometres in diameter. Today we know that it is about 13,000 kilometres in diameter.

So you see, human beings have spent a long time gathering evidence about the shape of the earth. Yet until even a few hundred years ago, there were many people who ignored this evidence, and believed the earth was flat anyhow, just because it appeared that way to the eye. But today you believe the earth is round, although it probably looks flat to you too. This is because you live in a modern society, one which bases its beliefs more and more on the scientific evidence that scholars and thinking people everywhere have at their disposal.

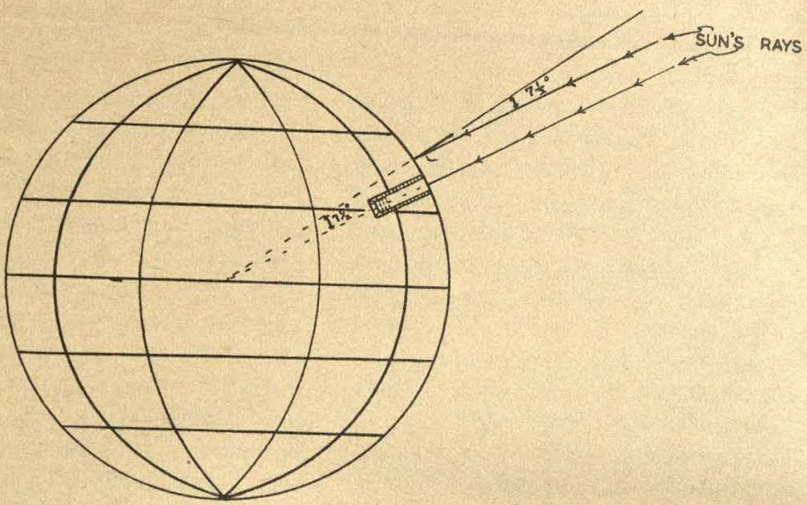


Fig. 1-15
Greek mathematicians calculated the size of the round earth more than 2,000 years ago.

***Show children pictures of earth photographed from man-made satellites and space ships. Let children study these photographs for additional evidence that the earth is round.***

## 2. THE EARTH ROTATES, CAUSING DAY AND NIGHT

Children have learned in previous classes that daylight and darkness are caused by the presence and absence of sunlight. The sun appears to move around the earth, rising in the east each morning, and setting each evening in the west. In reality, the earth rotates around its own axis from west to east. This is a question of relative motion. For many centuries men believed that the sun did move around the earth once each twenty-four hours. In this unit class III students can begin to see some of the evidence which eventually led to this modern point of view.

### 2(a). THE SIDE OF THE EARTH FACING THE SUN IS LIGHTED; THE OTHER SIDE IS DARK

Children have already done some activities related to this sub-concept. The ideas of day and night, of sunrise and sunset, and of the measurement of the time are all related to each other. Those earlier activities did not assume that the sun goes around the earth. Rather, the earth rotates. At this class level, students can begin to see why modern educated people believe this latter idea.

**Investigation**

## Why is it not day-time all over the earth at one time?

*Materials required*
bright light source, ball or round earthen jug, dark paper

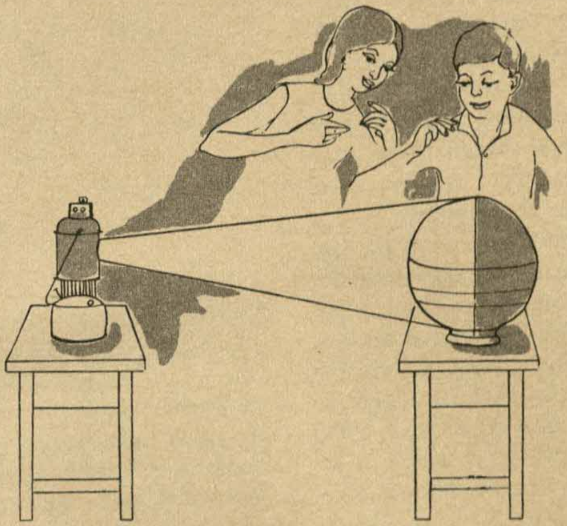


Fig. 1-16

The sun provides daylight for half of the earth at any one time.

Take the class out in the sun. Give a child a large round object, like an earthen jug. Let children look at its side facing the sun and also the side away from the sun. Now bring the class back to the room. Darken the classroom well. Arrange a strong source of light placed on the table somewhere in the middle of the room. Let the beam of light be narrow and in one direction only. This can be done by covering the lamp surface with black paper keeping only a small opening in it. Let a child hold the jug or place it on a stool of suitable height in the path of the beam of light, as in Fig. 1-16. Let others observe. Let the child rotate the globe. Let other children observe and find out which side of the globe is lit and which is not. Why is the side away from the source of light not visible?

**Investigation**

**Which moves, the earth or the sun?**

*Materials required*
bright light source,
round ball or round
earthen jar

Set up a bright source of light to represent the sun, and a round ball or jug to represent the earth. Remind children that the sun appears to rise in the east and set in the west. If it is assumed that the earth rotates to produce this effect, it should rotate anticlockwise as seen from a position above the North Pole, as suggested in Fig. 1-17. Now remind students of the size of the earth (nearly 13,000 kilometres in diameter). It may seem strange that such a huge object can spin at the rate of once each 24 hours. But now remind the students of the diameter of the sun (about 150,000,000 kilometres). Help them realize that it is much more strange that such a tremendous object—so far away, could be revolving around the earth once every 24 hours. This is one of the reasons that modern scientists believe the earth rotates on its axis.

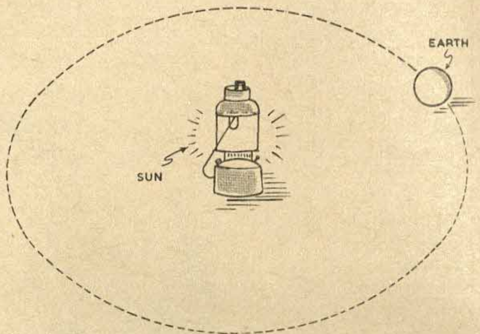


Fig. 1-17
It is easier to imagine the small earth moving than to imagine the huge sun moving.

*Engage children in a discussion on the question: Is it proper to speak of night-time as being in the shadow of the earth? (Yes.)*

*Discuss with children to get their original thoughts on the question: Are there conditions of day and night on the moon? (Yes, there are.)*

**2(b).** SUNLIGHT MOVES FROM EAST TO WEST BECAUSE THE EARTH ROTATES FROM WEST TO EAST

Children already know that the sun appears to rise in the east, move across the sky, and set in the west. Adults know that this is not really the case. Actually, the earth rotates on its axis from west to east. This gives the observer the impression that the sun is moving in the opposite direction with respect to the earth. This is a useful example of the concept of *relative motion*. Here are some activities which can help children understand this important concept as well as the effects of earth rotation.

### Discussion

### What is meant by relative motion?

Ask children to imagine two ships becalmed on an ocean far from land. The larger ship is ahead of the smaller one. When the sailors wake up next morning, the larger ship is *behind* the smaller one. What has happened? Has the larger ship drifted back or has the smaller one drifted ahead? A discussion will show that this all depends on the place of observation. Which ship has moved with respect to the other is a matter of relativity of motion.

### Investigation

### Which way does the earth rotate?

*Materials required*
bright light source,
large ball
or round earthen jug

Use a ball or a round earthen jug to represent the earth and a torch or a lantern or a well-lit window to represent the sun. Mark the position of India on the 'earth', and mark the directions of east and west on the model earth. Remind students that to be useful this model must account for the apparent rising of the sun in the east and its setting in the west. Challenge them to make the 'earth' rotate in such a direction that the sun appears to rise in the 'east', and eventually 'set' in the west. Help them to arrive at the conclusion that to achieve this, the model earth must be rotated from west to east, as in Fig. 1-18. This should not be regarded as a *proof* of the rotation of the earth. However, it is a useful experience to help students to arrive at this conclusion on the basis of their own reasoning.

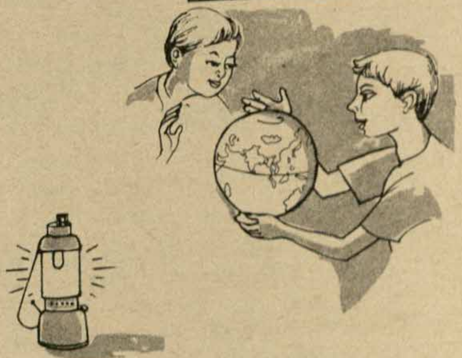


Fig. 1-18
The earth rotates anti-clockwise as seen from the north.

*Ask students to remember the impression they have when the bus they are riding begins to move? Does it seem as though the surroundings are moving backward?*

**2(c).** WHILE PEOPLE IN INDIA ARE HAVING DAY, THOSE IN AMERICA ARE HAVING NIGHT, AND VICE VERSA

Children have no first-hand evidence that at any moment only half of the earth is lit by the sun—that at any moment half of the earth is having day, while the other half is having night. Here are activities, however, which can help children see that this is true.

| **Investigation** | **How does the time of day differ in different locations?** | *Materials required*<br>bright light source, large ball or round earthen jug |
|---|---|---|

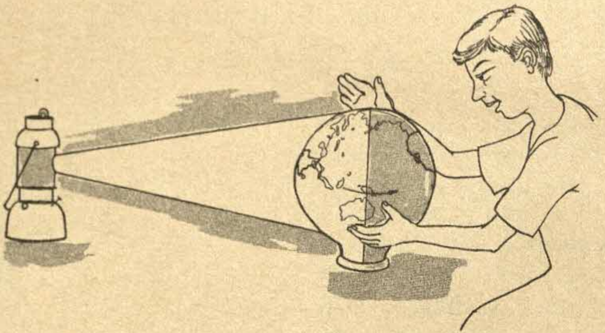


Fig. 1-19
When it is daytime in India it is night time in the Western Hemisphere.

Place a source of light somewhere in the middle of the classroom in such a way that it will send out a narrow beam of light. Let one child place a spherical object (earth model) in this beam of light and rotate it gently, as in Fig. 1-19. See that rough outlines of India and America have been sketched on the jug. When India is towards the light, let the class observe where America is. Let the children find out for themselves that when there is day in India, America has night. Now let America face the light. Let the children see where India is and learn that when there is day in America, it is night in India.

**2(d).** THE CLOCKS IN EAST PAKISTAN ARE HALF AN HOUR FASTER THAN THOSE IN INDIA; THE CLOCKS IN WEST PAKISTAN ARE HALF AN HOUR SLOWER THAN THOSE IN INDIA

For most children, local clock time is the *time.* They have no first-hand evidence to the contrary. Through well-selected activities, however, it is possible to help children see how local time is different at different points on the earth. Here are some examples.

**Investigation**

**How do clocks in India differ from those in Pakistan?**

*Materials required*
bright light source, large ball or round earthen jug

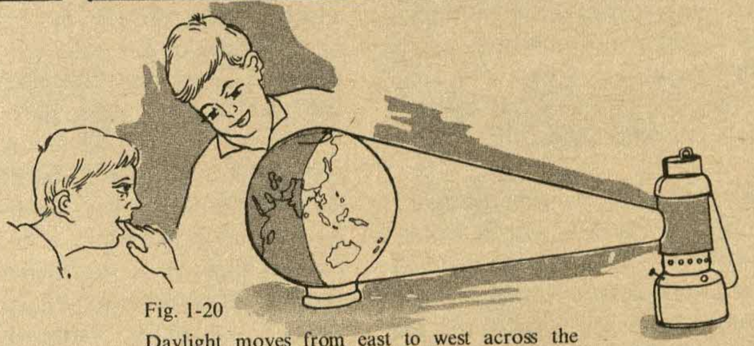


Fig. 1-20
Daylight moves from east to west across the Indian sub-continent.

Use a ball or a round earthen jug to represent the earth. Sketch an outline of India on the 'earth', and indentify the position of East Pakistan and West Pakistan. Let a child slowly rotate the earth from west to east, as in Fig. 1-20. Have the others observe whether Dacca (capital of East Pakistan) or Delhi comes into the light first. Let them learn in this way that East Pakistan has an earlier sunrise. This means that the clocks there are ahead. Let the globe be given a little more twist until Delhi just comes in light. Karachi (in West Pakistān) will be still in dark. This means that Karachi has late sunrise as compared to Delhi. Consequently clocks in Karachi are behind. Carefully note the position of the earth when the 'sun' is 'exactly overhead' for central India. Note that this represents the condition of noon. Help the children see that 'noon' occurs in central India after it occurs in East Pakistan, but before it occurs in West Pakistan.

*Help the class correspond with classes in schools* 100 *to* 200 *kilometres to the east and some in schools* 100 *to* 200 *kilometres to the west. Let all these three groups of children keep a careful record of the exact times of sunrise. They can exchange the observations with each other with the help of their teachers.*

### 3. THE MOON GETS ITS LIGHT FROM THE SUN

The moon is one of the most familiar objects in the sky. Yet it differs from nearly all the others in certain ways. For one thing, it is the closest heavenly object (except meteors, which are not permanent). Also, the moon produces no light of its own; it shines only by reflected light. It is like a white ball which can be seen only when some light falls on it—never when it is in the dark.

If there is a white ball outdoors on an extremely dark night it is visible if a torch shines on it. Only half of it—the half towards the torch—can be seen. The other side is invisible.

So it is with the moon. The side facing the sun is brilliantly lit. The dark side is usually completely invisible. Children in class III can be helped to understand this. Some may begin to comprehend the details of the lunar cycle and its phases. But all can learn that the moon is seen only by reflected light, and that the apparent change of the moon's shape is due to this fact.

**3 (a).** THE SIDE OF THE MOON WHICH IS TOWARDS THE SUN IS LIGHTED; THE REST OF THE MOON IS DARK

Nearly all the objects one ordinarily sees are well lit from all sides. All parts of their surface can be seen because some light falls on all parts. But when people on a dark night are seen only by the light from a fire or a lantern or a torch, the appearance is different. Now only the parts towards the light can be seen; other parts are invisible. This is the case with the moon. It is a sphere some 3,400 kilometres in diameter and nearly 400,000 kilometres from the earth. Only that half of the moon which is towards the sun can be seen; it is the lighted half. If the lighted half is towards the earth, the moon is called a 'full moon'. Often the lighted half is to the right side or to the left side of the line of sight. Then the moon appears to be a 'squashed ball', or a half circle, or crescent. Here are some activities which can help children understand these effects and their causes.

**Investigation**

**What is needed to make objects visible?**

*Materials required*
bright light source

Make use of a well-darkened room. Perhaps you can get children together on a field on a very dark night. Have children notice that they cannot see each other or common objects. Now shine a torch or a lantern on them. Ask them to explain why the objects are now visible.

**Investigation**

**Why does the moon appear to change its shape?**

*Materials required*
bright light source,
large ball or round
earthen pot

Shine a torch from behind the children on a white ball (or a white painted round earthen pot). See Fig. 1-21a. Help them realize that this corresponds to a full moon. Now swing the torch around so that it shines on the 'moon', but not directly in the line of sight, as in Fig. 1-21b. Note how this changes the apparent shape of the 'moon'. Challenge children to arrange the torch so that the 'moon' appears like a half circle or like a slender crescent.

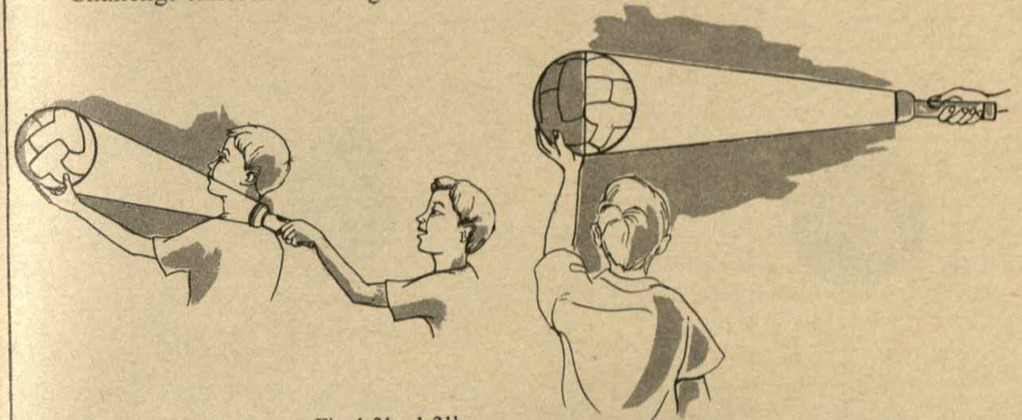


Fig. 1-21a, 1-21b
The moon seems to change its shape due to changes in lighting conditions.

*In a similar way, illuminate children's faces from different angles and notice the difference in appearance.*

### 3(b). AT THE TIME OF THE CRESCENT MOON, THE DARK PORTION OF THE MOON IS DIMLY VISIBLE

When the moon is nearly in the same direction as the sun, the moon appears as a slender crescent. At such times it is often possible to see the 'dark side' illuminated by light reflected from the earth. This condition is sometimes called 'the old moon in the new moon's arms'. Here are ways to help children understand this interesting and lovely sight.

| | | |
|---|---|---|
| **Investigation** | **Why is the full moon sometimes dimly visible with the crescent moon?** | ***Materials required***<br>**bright light source, large ball or round earthen jug, white paper or cloth** |

Illuminate a white sphere with a bright torch, as in Fig. 1-22a. Note that the 'dark side' of the sphere is scarcely visible. On a very dark night it would be completely invisible. Now hold a white paper or cloth so that the torch shines on it as in the sketch. Note how torch light reflected from the white surface makes the dark side of the sphere visible, as in Fig. 1-22b. Help students see that a similar situation produces, 'the old moon in the new moon's arms'.

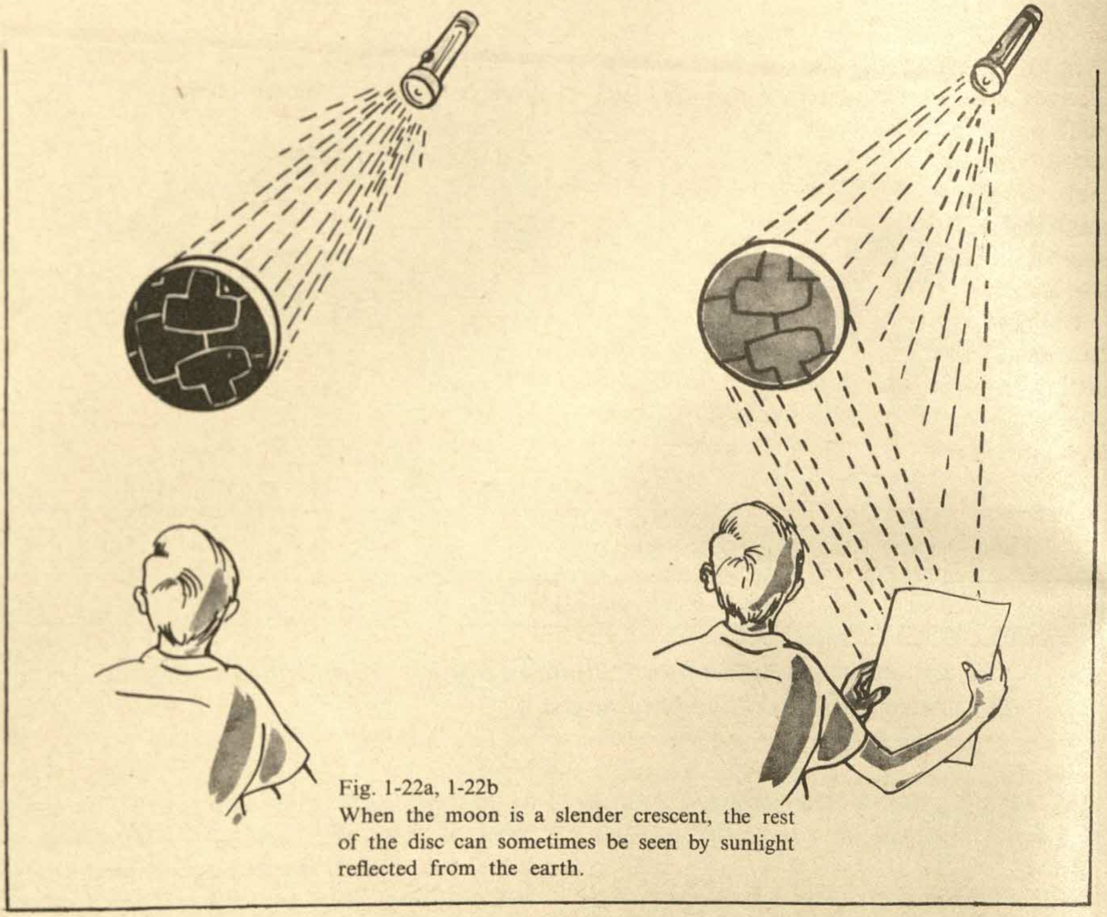


Fig. 1-22a, 1-22b
When the moon is a slender crescent, the rest of the disc can sometimes be seen by sunlight reflected from the earth.

*Shine a torch on the white wall of a darkened room. Note how light reflected from the wall makes many things throughout the room slightly visible.*

### For Better Understanding

Why should the larger part of the moon appear much dimmer than the crescent even though it also is receiving reflected light? The bright crescent reflects back direct sunlight which it receives from the sun. In the case of the other portion of the moon, it only receives reflected light coming from the earth. This light is the light of the sun reflected from the earth. It is much weaker than direct sunlight. Thus the part of the moon which is not in the crescent receives weak light. When this weak light is reflected back, it appears even more weak. The observer on the earth receives this very weak light coming from the 'full' portion of the moon and therefore sees it but dimly.

### 3(c). WHEN THE MOON IS FULL, THE EARTH LIES BETWEEN THE SUN AND THE MOON; THE NEW MOON IS ALMOST ON A LINE BETWEEN THE SUN AND THE EARTH

Children can perceive the first of these two ideas clearly and easily. As the sun is setting in the western sky, the full moon comes up on the horizon in the eastern sky. Thus the sun and the moon are on opposite sides of the earth. The second phenomenon needs more careful observations. Such observations can be made on the first few days of the lunar month. On the first day the crescent is difficult to see. But on the second and third day of the lunar month the crescent is seen in the western sky very soon after sunset. This shows that at the time of new moon, the sun and the moon are on the same side of the earth. Children can make observations like those suggested below and discover this for themselves

**Field Observation**

**Where do we find the full moon?**

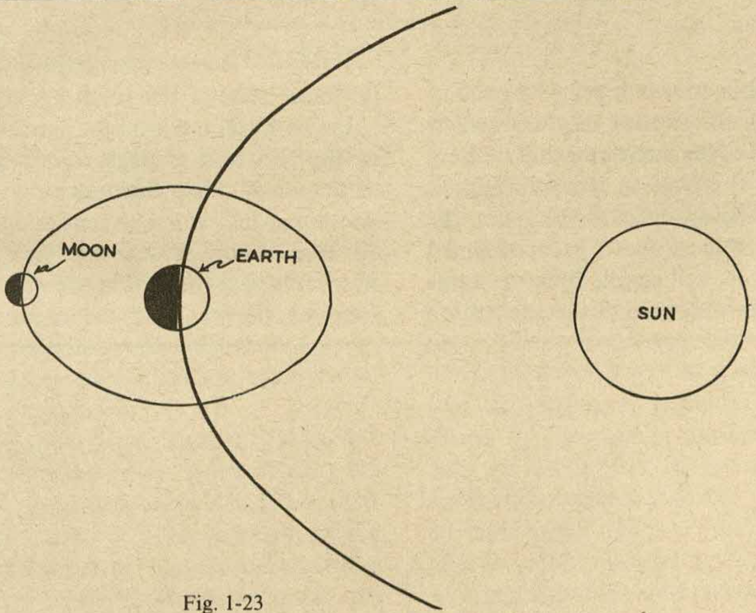


Fig. 1-23
The full moon is seen when the earth is between the sun and the moon.

Remind children when it is full moon. Ask them to observe the moon in the evening and in which part of the sky it is seen. Let them report their observations to the class the next day. Encourage some children to draw a sketch showing the respective positions of the sun, the earth and the moon.

It will become clear to them that the earth is between the sun and the moon, as in Fig. 1-23. Ask pupils to pursue this activity for 2 or 3 more days while the moon is nearly full.

**Investigation**

### Where do we find the crescent moon?

*Materials required*
bright light source,
round object

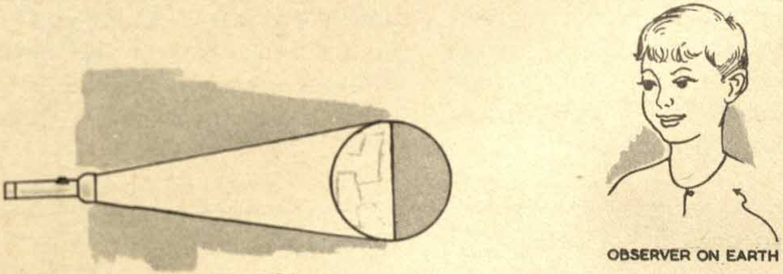


Fig. 1-24
When the moon appears as a crescent, it lies nearly between the sun and the earth.

Ask pupils to watch where the moon appears in the sky for the first two or three days of the lunar month. Let them report to the class in which direction they saw the moon in the sky, i.e., the direction of moonrise. Their combined observations will enable them to agree that the new moon and the sun are on the same side of the earth.

Let children use a bright light source as the sun and a large round object as the moon. Help them set up a classroom model of a crescent moon, as in Fig. 1-24. When this has been accomplished, note that the moon is between the sun and the earth.

# UNIT 1

# OUR UNIVERSE

INSTITUTE OF EDUCATION FOR WOMEN
Dept. of Extension
SERVICE
CALCUTTA-27

## CLASS IV

### Overview

Class III approach had three important differences from the earlier classes. These were:

Passive *observation* is supplemented by *experimentation.*

Study of *phenomena* (effects) is supplemented by study of the *causes* of these effects.

Learning about *changes* is supplemented by learning about the *patterns* in which changes so often occur.

These trends continue in class IV. Here, there are more complex kinds of experimental investigations to be done; there are some more involved cause-and-effect relationships, and the patterns of changes are more subtle and more complicated.

In this class, children learn of the earth's hot interior. They also learn about the nature of the sun. They learn a little about its tremendous source of energy, and how the energy gets to the earth. They learn something of the nature of the stars, of their size and distance, and of the nature of their energy. For the first time they begin to make a meaningful association between the stars and the sun; they begin to see the sun as a rather ordinary star; different from the others only in that it is relatively near the earth.

They also learn of the earth's position as one of the nine planets revolving around the sun. All these motions result in many changes in the apparent positions of objects in the sky. Although these changes are extremely complex, they can be understood, and they can be predicted.

Here students consider their previous observations and other bits of knowledge about the yearly cycle of seasons. They learn that the pattern of seasonal change is produced by the relative positions of the sun and the earth, and by the motions of the earth with respect to the sun. They also begin to understand some of the very profound effects which seasonal patterns have on the lives and activities of human beings.

### 1. THE EARTH IS ONE OF THE NINE PLANETS MOVING AROUND THE SUN

Children in class IV already know quite a bit about the earth. They know that it is a huge ball. They know that it rotates on its axis causing day and night. They are aware of the fact that the earth travels around the sun, and that this motion helps produce the yearly cycle of seasons. Students now have a chance to see the earth not so much as a huge ball on which people live, but as one of the nine planets which revolve around the sun.

### 1(a). A PLANET IS A BODY THAT REVOLVES AROUND THE SUN

The sun is the central object of a huge system. This system includes the sun and nine planets and other objects too. The earth is one of the planets. When any one looks into the night-time sky, he sees many points of light. Usually, these are all called *stars*. Actually, while most of them are stars, there are a few which are not. These are bright objects which gradually move with respect to the rest of the night-time sky. These wandering objects are *planets*. Because they are in motion around the sun, they appear to move across the background of stars.

The earth is one of the nine planets belonging to the sun. Its motion around the sun helps produce the yearly cycle of seasons. Here are some activities which will help children understand the general idea of planetary motion.

**Investigation**

**What is the relation between a planet and the sun?**

In a room where there is plenty of space or out-of-doors, select one student to stand motionless. He corresponds to the sun. Now ask another student to walk in a circle with the first standing at the centre of the circle, as in Fig. 1-25. The walking student corresponds to a planet. The student should be directed to walk in a direction which corresponds to real planetary motion. This direction is counterclockwise as seen from above.

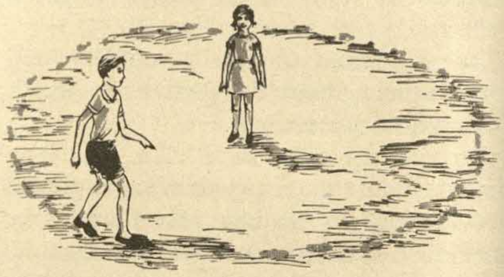


Fig. 1-25
A planet goes around the sun.

**Investigation**

**What is the direction of the motion of a planet?**

*Materials required*
string, block of wood or soft rubber ball

Tie a block of wood or a tubber ball to the end of a piece of string about one metre long. Invite a student to swing the ball around his head at the end of the string, as in Fig. 1-26. The student now corresponds to the sun. The ball corresponds to a planet which revolves around the sun. Care should be taken that the ball is swung in a direction corresponding to the real planetary system. This direction is counter-clockwise as shown in the figure.

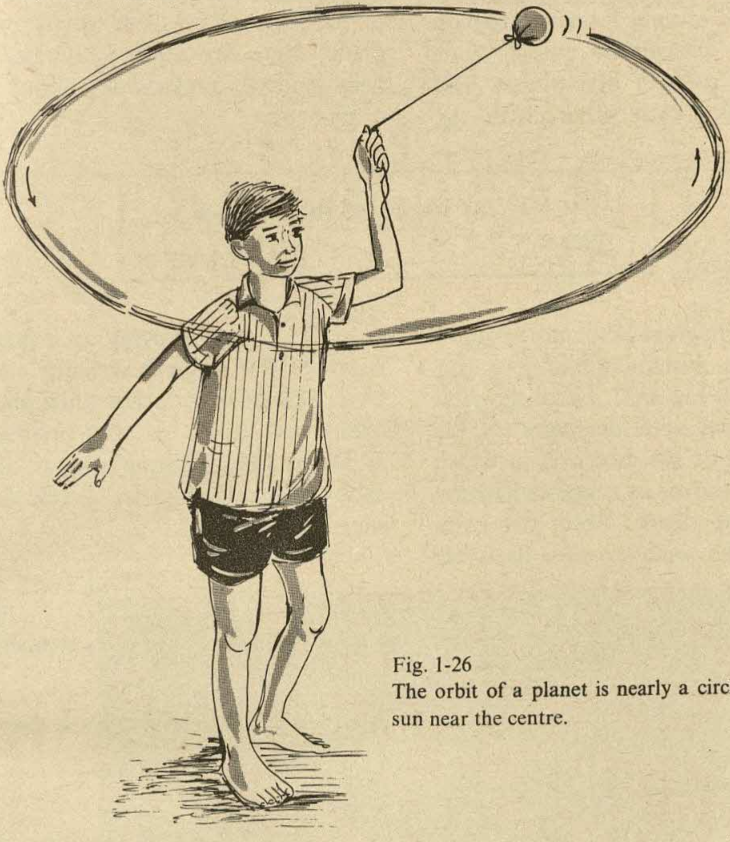


Fig. 1-26
The orbit of a planet is nearly a circle with the sun near the centre.

*Challenge students to tell which part of a revolving bicycle wheel corresponds to a planet, and which part corresponds to the sun. (Any spot on the tyre corresponds to a planet; the hub or axle corresponds to the sun.)*

**For Better Understanding**

In these activities the orbits of planets have been regarded as circles. It is true that planetary orbits are not perfect circles. Instead they are ellipses—slightly flattened circles. However, the orbits of most planets, including the earth, are very nearly perfect circles. Children can be told that planetary orbits are almost circles.

### 1(b). EACH PLANET TRAVELS IN ITS OWN ORBIT

Each of the nine planets of the solar system has a definite path around the sun. Its path is nearly a circle, actually an ellipse. Each path is called the *orbit* of that planet. The orbits do not cross each other, with the exception of the orbits of the last two planets. Each planet stays in its own orbit. The orbits of the nine planets are nearly in the same plane. Here are some activities which can help students understand about the orbits of planets.

**Investigation**

**What is the nature of the orbit of a planet?**

Prepare a diagram of the nine planets of the solar system, something like that shown in Fig. 1-27. Label the orbit of each planet with the name of the planet. Indicate the direction in which each planet moves as suggested by the arrows in the sketch. Point out carefully that this is *not* a scale drawing. To make a scale drawing on a sheet of paper of this book is virtually impossible. Also point out that while planets' orbits are shown as flattened circles in almost all textbooks, most of the orbits are nearly circular, as this sketch suggests.

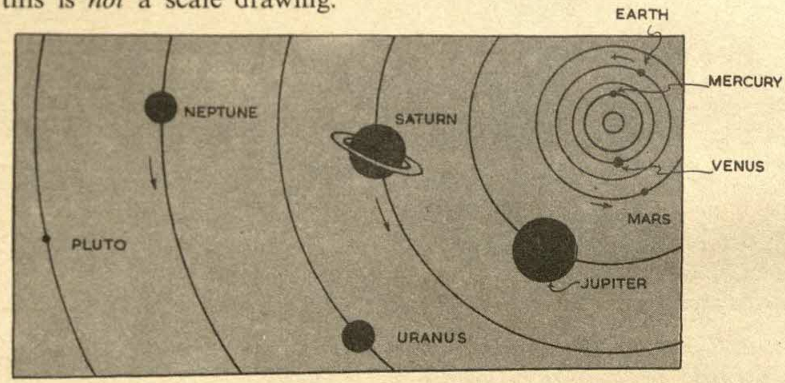


Fig. 1-27
The planet's size and distance from the sun here are *not* to scale.

**Investigation**

**What are the orbits of the four inner planets like?**

Select an area of the playground where there is plenty of space. Ask a student to stand and represent the sun. Now place four students in the four orbits of the four inner planets, as suggested in Fig. 1-28. Have them move

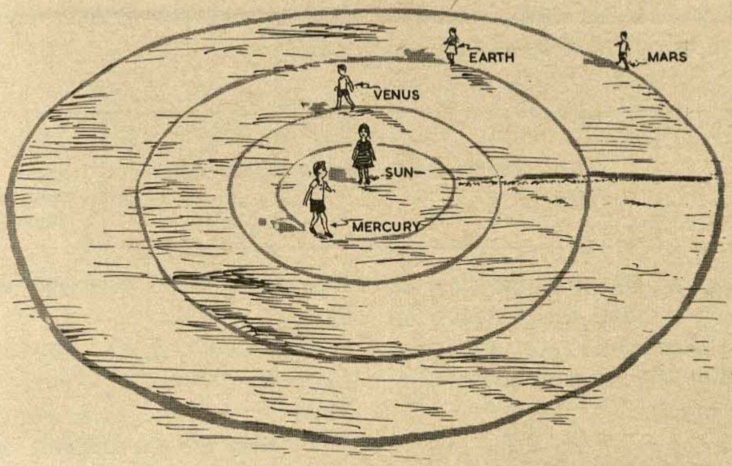


Fig. 1-28
The orbits of the 4 inner planets are somewhat evenly spaced.

in counter-clockwise direction as seen above. The innermost planet, Mercury, should make a revolution around the sun in its small orbit more quickly than any other planet. Venus is a slower moving planet. The earth moves more slowly still. Of the four inner planets, Mars moves most slowly.

*Find out the names of the planets in the language of your region. Help students prepare a chart which shows the planets along with their regional and Hindi and English names.*

### **1(c).** THERE ARE NINE PLANETS

There are nine known planets in the solar system, including the earth. It is possible that there are other planets besides these, and some astronomers continue to look for them. (The names of the planets, in their order outward from the sun, are shown in Fig. 1-27). The planets vary in size. The smallest is Mercury. Its diameter is about 2/5th of the diameter of the earth. The largest planet is Jupitar, with a diameter about 11 times that of the earth.

There is little educational value in having students memorize the names of all the nine planets. However, it is interesting for them to know that the innermost planet is Mercury and the outermost planet is Pluto. They might also be interested in knowing that Mercury is the smallest planet and Jupiter the largest. It is important for students to realize that the earth is a medium sized planet and is the third out from the sun.

Its distance from the sun is nearly 150 million kilometres; this is also important. Students can be helped to become familiar with the general layout of the planets in the solar system through activities such as these.

**Class Project**

**How can we make models of the nine planets?**

*Materials required*
balls of various sizes,
round balloons,
plastic clay

Organize the efforts of the class to prepare approximate scale models of each of the planets. Their diameters with respect to the earth are shown in the list below:

| | |
|---|---|
| Mercury | 2/5 |
| Venus | 19/20 |
| Earth | 1 |
| Mars | 1/2 |
| Jupiter | 11 |
| Saturn | 9 |
| Uranus | 3-3/4 |
| Neptune | 3-1/2 |
| Pluto | 1/2 |

These sizes are approximate only, but they are completely adequate for students' work at this level.

**Discussion**

**How far are the planets from the sun?**

Prepare a chart of the planets of the solar system as suggested in Fig. 1-29. For each planet there should be a place to put its name, its diameter, its distance from the sun, and a column for remarks. The approximate average distance from the sun of the nine planets is shown in the table below:

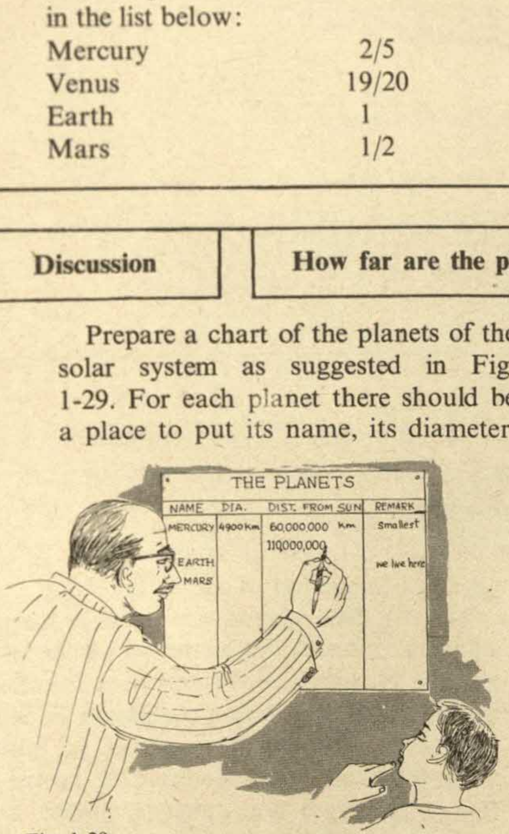


Fig. 1-29
It is interesting to make a chart of what we know about the solar system.

| | |
|---|---|
| Mercury | 60 million kilometres |
| Venus | 110 million kilometres |
| Earth | 150 million kilometres |
| Mars | 230 million kilometres |
| Jupiter | 780 million kilometres |
| Saturn | 1,400 million kilometres |
| Uranus | 2,900 million kilometres |
| Neptune | 4,500 million kilometres |
| Pluto | 5,900 million kilometres |

*Urge children to look for the common planets in the night-time sky. They can get help from their parents or from the newspapers in finding them. Many of our newspapers publish articles about the appearance of the night-time sky on the first or the second day of each month.*

## For Better Understanding

Man has known about planets almost since the first time he turned his eyes towards the sky. However, he did not know all of the planets which scientists know today. The ones he could see with his naked eye were Mercury, Venus, Mars, Jupiter, and Saturn. Uranus is just bright enough to be seen on a very clear night by a person with very good eye-sight. However, no observer ever reported having seen it until after the development of telescope.

Early observers did not consider the earth as one of the planets. They spoke of the other five as 'wanderers' from which the name 'planets' is derived. The names used on these pages for the most part are developed from the mythology of the Greeks. Ancient people living in India and in other parts of the world had their own names. However, all civilizations of a few thousand years ago knew about the five planets in addition to the earth.

It is possible to make scale models of the planets, with proper attention to their relative size. It is also possible to make a scale drawing or model of the *distances* of the planets from the sun. However, to follow both of these scales at the same time requires a very large space. It can be done out-of-doors, but it is a difficult job, and somewhat beyond the understanding of class IV students. However, students should realize that the drawings used in this teachers' handbook as well as in the texbooks which they use, are not accurate scale drawings.

**Scientists at Work**

## Early scholars develop the idea of a moving earth

Of all the things you know, which is the one least likely to move to a new position? Is it the large tree near the school or perhaps the oldest house in the village? May be, you think a nearby lake will not move or that our country will not move. Surely you will agree that nothing is more fixed—less movable—than the very earth on which we live. For many thousands of years, early people of all countries thought the earth was motionless. After all, you can hardly blame them.

Some of the early civilizations had interesting ideas of what the earth and the heavenly objects really looked like. A diagram of one such idea is shown in Fig. 1-30. The earth is a ball located in the middle of everything. Around it goes the moon, in a nearly circular path. Next comes the sun, which moves around its path exactly once each day. Two planets, Mercury and Venus, come next, although they are arranged so that they never get very far away from the sun. Next come three more planets—Mars, Jupiter, and Saturn. No other planets were known until a few centuries ago. Finally, all these heavenly objects are surrounded by a huge sphere, and the stars are on this sphere. This starry sphere went around the earth just a little bit faster than the sun. The ancient people did not worry about what made the heavenly objects move nor why they stayed in their own paths. They thought the universe was laid out in this pattern 'just because it was that way'. And above all, they thought the earth was in the centre of 'everything', and that it did not move. Of course, the earth, being in the centre of the universe, was obviously the most important part of all.

As man's knowledge of the movements of heavenly objects grew, he realized that the paths of these objects were not simple circles. So, as time went by, the model of the arrangement shown in Fig. 1-30 became more and more complicated. By the sixteenth century, the beliefs of scientists were so complicated that very few people in the world could understand them. They were so complex that they could hardly be drawn, even in a very elaborate sketch.

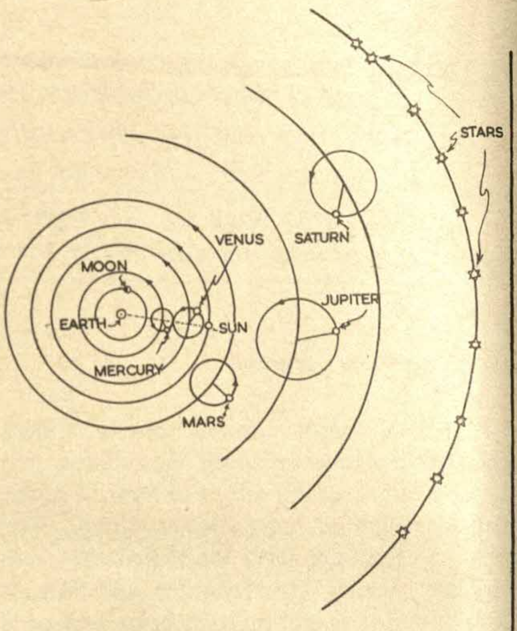


Fig. 1-30
Most ancient people believed the earth to be in the centre of the universe. This sketch is typical of what many people thought from about 2,500 years ago until less than 500 years ago.

Early in the sixteenth century, a brilliant young Polish astronomer named Copernicus was giving serious thought to this problem. Copernicus was a Christian priest. Being a deeply religious man, he felt that the Creator was an all powerful being. He could not understand why the all powerful Creator should have made the universe such a complicated system. So, he began to think about another kind of universe-system. It was one which had been proposed by the Greeks nearly two thousand years earlier, but had not been accepted by them. In this system the sun is at the centre. Around it go

Mercury and Venus, then the earth. The moon goes around the earth. After the earth come Mars, Jupiter, then Sautrn and finally the stars. But in this system, the stars do not move. Instead, their apparent motion is due to the fact that the earth rotates on its axis once every twenty four hours. This earth rotation also accounts for the apparent motion of the sun around the earth.

This, of course, is basically the system that all modern people believe in today. But when Copernicus proposed this system more than four hundred years ago, it raised a great deal of controversy. People could not accept the idea that the earth could move. And they did not like the notion that the all important earth—the home of man—was not at the centre of the universe.

It was more than a hundred years after the death of Copernicus before most of the thinking people of the world were ready to accept these modern ideas about the universe. It takes a long time for an idea to grow. You are accustomed to seeing plants and animals grow. You know that you yourself are growing over a period of years. Now you can see that ideas and concepts also grow and change. Some of them change very slowly indeed.

How about ideas in your own mind? Do you cling to old ideas and traditions without considering new kinds of thinking? Or, like modern scientists, do you keep your mind open to accept a new idea when it comes along, provided there is good evidence to support it?

## 2. THE EARTH IS VERY HOT INSIDE

At most times of the day the earth below the surface is somewhat damp and relatively cool. However, as one goes deeper and deeper, the earth becomes warmer and warmer. This is true in all parts of the world. Along with other evidence, this leads scientists to believe that the deep interior of the earth must be extremely hot indeed. The two sub-concepts which follow are intended to help students understand conditions inside the earth better.

### 2(a). THERE IS GREAT PRESSURE INSIDE THE EARTH

Children already know that there is pressure beneath liquids. They know that the pressure under water is due to the weight of the water above. They also know that atmospheric pressure is due to the weight of the atmosphere.

Based on the same kind of logic, there should be pressure beneath the surface of the earth. Since this pressure depends on the weight of material above, it follows that the pressure deep down below is very great indeed. Except for caves near the surface, there are no hollow spots inside the earth. The pressure is so great that no holes can exist. Activities such as these can help students accept the idea of enormous pressure beneath the earth.

**Investigation**

**What produces pressure beneath the earth's surface?**

Permit a child to lie on the ground and let other children pile sand on his arms and legs. Let him report to others when he begins to feel a pressure. After the sand is thirty or forty centimetres thick, allow one child to sit on top of the piled-up sand. The child who is lying down can feel the increased pressure. This is due to the increased weight above him. Help children realize that the deeper one goes in the earth the greater is the pressure. See Fig. 1-31.

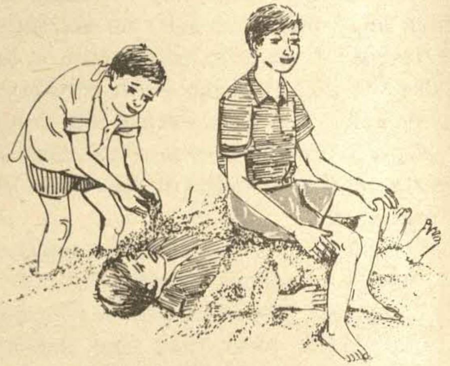


Fig. 1-31
Pressure beneath the surface of the earth is produced by layers of rock and soil above.

*Show pictures of a gusher type oil well. Remind students that the liquid petroleum is being forced out of the earth by the very great pressure deep down where the oil is.*

**For Better Understanding**

The pressure beneath the surface of the earth increases with depth. Even at depth of a few hundred metres, it is necessary to provide very strong braces for mines where coal, salt or other minerals are removed from the earth. The increase in temperature is also very noticeable to miners. For mines which are more than a few hundred metres deep, it is common to blow fresh cool air through the openings so that the working conditions will be bearable.

The combination of pressure and temperature beneath the earth's surface produces unusual effects. At depth of several thousand meters the temperature may be high enough to melt some parts of the rock of which the earth is made. However, the enormous pressure prevents this rock from becoming a liquid. As a result, there is an unusual situation where rock is hot enough to be a liquid, but because of very great pressure, cannot behave as liquids do.

**2(b).** VOLCANOES ERUPT AT WEAK PORTIONS OF THE EARTH'S CRUST

Most children have never seen a volcano in action. However, they have read about them and seen pictures of them. They often have the idea that in some mysterious way the earth opens up and red hot liquid rock or *lava* comes forth. Since most volcanoes are in mountainous regions, children often think that the inside of mountains may be liquid rocks under pressure. Children sometimes say that when there is a crack the liquid lava comes squirting out like tooth paste from a tube when it is squeezed. These are examples of false impression of volcanoes.

As indicated in "For Better Understanding" above, regions beneath the surface of the earth are extremely hot. However, the pressure is so great that the rock cannot melt. But, if there is a weakness in the earth's surface, or if an earthquake produces some cracks near this very hot lava, then the pressure is released and the melted rock comes out. This often happens in mountainous regions. However, it may also occur in the middle of a plain or even underneath the ocean. As the rock continues to flow, it often builds its own mountain or volcano. Activities such as these can help students understand the behaviour of volcanoes.

**Investigation**

### What makes a volcano erupt?

*Materials required*
plastic bag, wet mud

Fill a plastic bag with a loose mixture of water and soil to make mud. Close the mouth of the bag carefully. Now subject the bag to mild pressure with the hand. Although the mud inside the bag is under pressure it cannot come out because of the strength of the surface, as shown in Fig. 1-32a. If now the opening of the bag is permitted to leak, or if a cut is made in the bag with a knife, the muddy material inside is free to come out, as in Fig. 1-32b. This is a crude analogy of the process that takes place in a volcano.

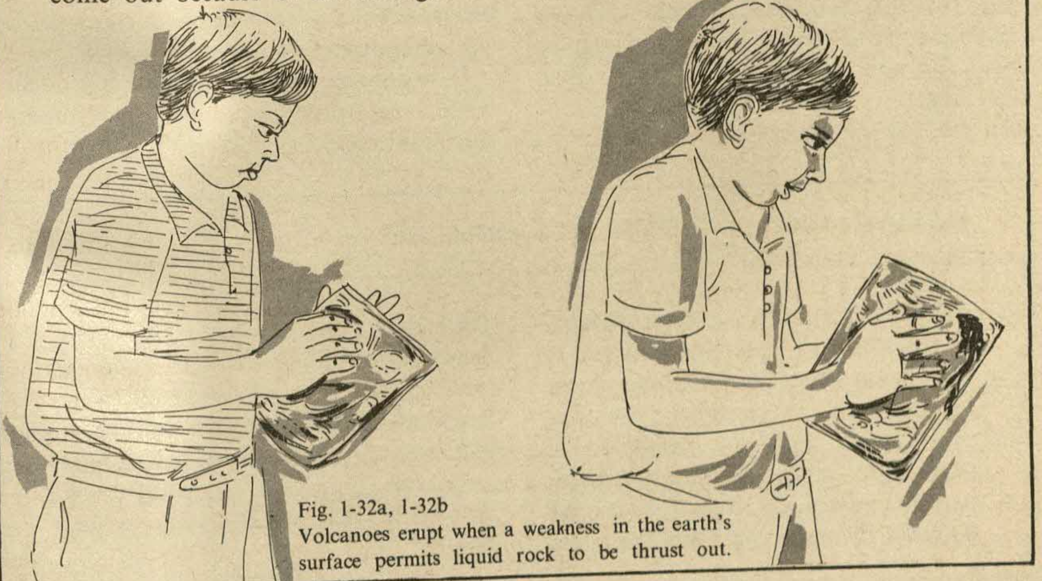


Fig. 1-32a, 1-32b
Volcanoes erupt when a weakness in the earth's surface permits liquid rock to be thrust out.

*Ask children if they or their parents know of any place in the vicinity where there is a hot spring. Point out that the heat for such a hot spring comes from lower layers of the earth where the temperature is very high.*

**For Better Understanding**

In the activity above, the analogy between mud and a plastic bag and liquid rock beneath the surface is a limited one. The rock beneath the surface is hot, while the mud inside the plastic bag is not. Beneath the surface of the earth hot rock remains as solid because of the very great pressure. There is no corresponding condition inside the plastic bag.

## 3. THE SUN IS A HUGE HOT BALL

Children have learned in previous classes that the sun is the source of heat and light for the earth. They know that the sun is a sphere and that it is extremely large. They often associate the sun with 'a giant ball of fire'. At this class level, students will have a chance to review what they already know about the sun and to add more to that knowledge.

### 3(a). THE SUN'S SURFACE IS EXTREMELY HOT

The temperature of the sun almost escapes the imagination. The sun is coolest near the surface. Its temperature there is about 6000°C. Farther and farther below the surface the temperature becomes much higher. It is believed that the temperature deep inside the sun is hundreds of millions of degrees.

Here are activities which will help students begin to get some idea of the intense temperature of the sun.

**Field Observation**

**What is a carbon arc?**

Take students to a cinema theatre. Get permission from the manager so that the students may see one of the arc lamps in a projector. Note that two carbon rods are permitted to touch each other. An intense electric current passes through the contact between the rods and heats their tips. The rods are then separated a bit and a heavy current flows through the space between the tips of the rods. The temperature in such an arc is the highest temperature that has been maintained on earth. Even this temperature is well below that of the surface of the sun.

*Permit students to observe an electric welding shop in operation. Be sure their eyes are protected from the intense light. The spark where the welding is actually being done is hot enough to melt steel. This temperature is well below that of the sun's surface.*

*At the welder's shop observe the appearance of an extremely hot piece of iron. This iron is usually not hot enough to melt. Yet it is extremely hot by earthly standards. Its temperature is far less than that of the surface of the sun.*

### 3(b). THE SUN'S ENERGY COMES FROM NUCLEAR REACTIONS

Children often have the idea that the sun is a 'huge ball of fire'. Actually the sun is not *burning* in the ordinary sense of the word. That is, there is no combustible fuel which is burning in an atmosphere of air or a similar gas. The source of the sun's energy is much like that of a nuclear bomb or of a nuclear reactor. The process is extremely complicated —far beyond the level of understanding of class IV students. At this level, it is sufficient for students to know that sun's energy comes from nuclear sources, not from the simple chemical burning of fuel. Activities like these can help students comprehend this idea.

**Discussion** **What is the nature of the nuclear fuel?**

Secure some newspaper or magazine articles about nuclear energy. These may relate to nuclear explosions (atomic bombs) or to a nuclear reactor, such as that near Bombay. Discuss with students the source of the energy. It is usually a chemical element known as uranium. Help children understand that the 'fuel' for a bomb or a nuclear reactor is not a fuel like petrol or diesel oil or wood or coal—one which burns in the chemical sense of the word. Rather, it is made of a special material where the nuclei of the atoms split. In this splitting (fission) process great quantities of energy are produced.

*Display pictures of the sun along with pictures of nuclear power plants as found in India or in other countries. Remind students that the basic source of energy for each is similar and that it is not a reaction of chemical combustion (burning).*

## 4. THERE ARE BILLIONS AND BILLIONS OF STARS IN THE SKY

On a very clear night it is possible for a person to see about four to six thousand stars with the naked eye. Another four to six thousand are below the horizon. That is, the human eye, without the aid of the telescope, is able to see perhaps 10,000 stars. Scientists know, however, that there are far more stars than these. With telescopes, they have been able to estimate that there are perhaps 10,000,000,000,000,000,000,000 stars! Such figures are only estimates; no exact count of all the stars that exist has ever been made. Probably such a count will never be possible.

### 4(a). STARS ARE INVISIBLE DURING DAY-TIME BECAUSE OF THE INTENSE LIGHT OF THE SUN

Children have learned in earlier classes that stars are present in the sky all the time. However, their light is so weak that they are completely blotted out by the bright blue light of the day-time sky. Here are some activities which can help children realize this.

**Field Observation** **What happens to stars in the day-time?**

Encourage children to get up some morning early enough to see the sky before all the stars have disappeared. Challenge them to fix their attention on the brightest stars in the western part of the morning sky. How long can they continue to see these stars? Is there any reason to think that the stars cease to exist when they can no longer be seen?

*Remind children how the light given off by a glowing coal or the end of a cigarette may be invisible in the bright sunshine. In a similar way, the light given off by stars is made invisible by the intense light of the day-time sun.*

### 4(b). STARS ARE HOT, GLOWING BALLS

Children have already learned that the sun is a star. The difference between the sun and other typical stars is merely that the sun is relatively very close to us. In this sub-concept children will have a chance to learn how other stars resemble the sun.

The sun is a rather ordinary star. It is neither the largest nor the smallest, neither the brightest nor the dimmest. The feature which distinguishes it from other stars is that it is near the earth. Here is an activity which can help children understand this.

**Familiar Experience**

**Why does the sun seem so much brighter than other stars?**

Remind children how a bright light at night looks fairly dim if it is very far away. This is the situation with stars, even though many of them are far larger and far brighter than the sun. However, they are not seen very well because they may be millions or billions of times farther away than the sun.

*Remind children that stars are not objects with five or six points as they are often drawn. Each star is a sphere. Even through the most powerful telescope made, every star looks like a point—a single point of light.*

### 4(c). ALL STARS EMIT HEAT AND LIGHT

Like the sun, all stars give off heat energy and light energy. It is obvious that stars give off light energy; otherwise they could not be seen. However, it is difficult for children to accept the fact that stars also give off heat. Here are some activities which can help children understand this.

**Investigation**

**Why do we not feel heat from the stars?**

*Materials required*
candle or kerosene lamp

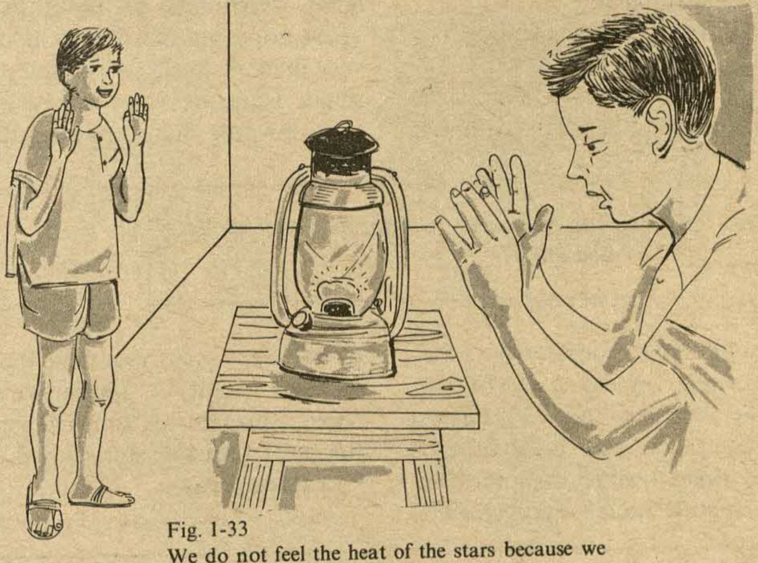


Fig. 1-33
We do not feel the heat of the stars because we are too far away from them.

Light a candle or a kerosene lantern. Invite children to hold their hands or face close enough to it so that they can actually feel the radiated heat. Now permit them to try to feel this heat from a distance, as in Fig. 1-33. They can no longer feel it, because the source of heat is so far away from them. In a similar way we cannot feel the heat given off by stars because they are so far away. Even though the heat cannot be felt, it is still there, just as in the case of a small flame a few metres away from the children.

*Remind children that they are not warmed by a fire unless they are quite close. However, children will agree that a very distant fire gives off heat, even though it cannot be felt from a distance.*

**For Better Understanding**

It is true that there are some objects in the sky which do not give off light. Some of these are known as 'dark stars'. These cannot be seen. However, astronomers can tell of their presence by observing the gravitational pull on a nearby visible star. With the exception of 'dark stars', all stars emit both heat and light.

**4(d).** THE SUN IS THE STAR NEAREST TO THE EARTH

The nearest star—the sun—is nearly 150 million kilometres from the earth. Although this seems like a very great distance it is nothing as compared to the distance of the other stars. The next nearest star to the earth appears to be quite dim. Its distance from the earth is about 40 trillion kilometres—40,000,000,000,000 kilometres. The other stars are farther away than this; some are many thousands of times farther away. These concepts of very great distances are very difficult for class IV children to understand. Here are some activities which can help towards that understanding.

**Discussion**

**Can we make a scale model of stellar distances?**

Invite children to consider the possibility of a scale model to include the earth, the sun and the next nearest star. The nearest star is about 250 thousand times farther than the sun. Thus, if a scale model were made, a given point might represent the earth. Another point, 1 centimetre away, could represent the sun. On this scale the next nearest star would be $2\frac{1}{2}$ kilometres away.

*Explore with children what is meant by the term 'light year'. It is the distance light travels in one year. Light travels at* 300 *million kilometres per second. In one year about* 10 *trillion kilometres*—10,000,000,000,000 *kilometres. Most stars are so far away that it is more convenient to measure their distances in light years than to measure the distance in kilometres. The nearest star is about* 4 *light years away. The sun is about* 8 *light minutes away.*

### **4(e).** SOME STARS ARE IN GROUPS CALLED CONSTELLATIONS

Over the centuries men observing the stars have found it convenient and interesting to group them into familiar looking patterns. These patterns are called the *constellations.* Early Indian people—five thousand years ago and more—had already grouped stars into constellations. Many of the constellations known to the Greeks, to the Romans and later on in the western hemisphere, have had their origins in the early stories and myths of ancient Indian people.

Most children have had a view of common constellations pointed out to them. Here are some activities which can make children more aware of the constellation pattern in the sky.

**Investigation**

**Let's make constellation models**

*Materials required*
cardboard box, pin, light source

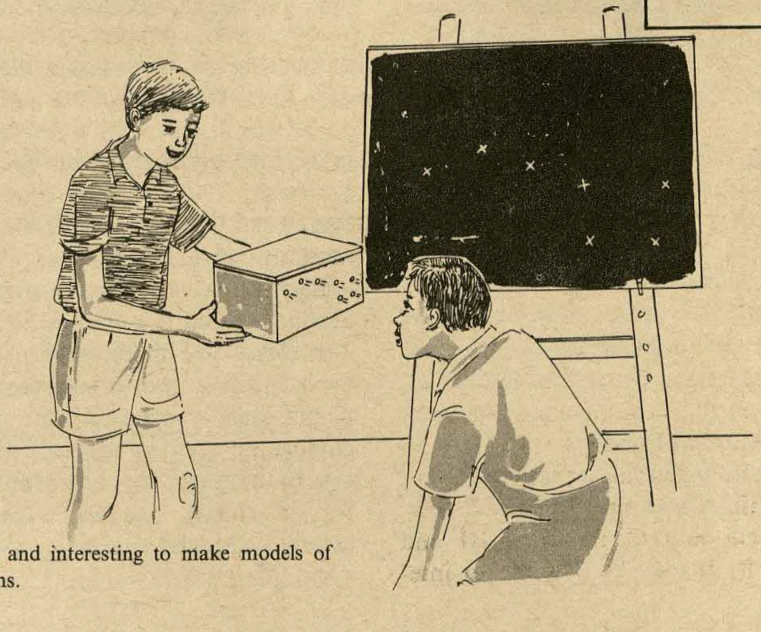


Fig. 1-34
It is simple and interesting to make models of constellations.

Select a few common and simple constellations. Draw their patterns on the chalk board or on a large paper so that all students may see. Allow groups of students to take a cardboard box and a pin, and to punch holes into the end of the box in the pattern of a given constellation. If now a light is placed inside the box, the pattern of the constellation shows through in a darkened room. See Fig. 1-34.

*On a clear night invite children to look at stars. Challenge them to use their imaginations to select other groups of stars which suggest familiar patterns. In this way, they are literally 'inventing' constellations. All constellations are really inventions of the mind of man.*

**For Better Understanding**

The stars which make up a constellation do not belong together. They are not all at the same distance from the earth, and they have nothing in common. The only thing is that they are in the same general direction in the sky. In a given constellation one star may be hundreds of times as far away as another star. It should be borne in mind by students and teachers that constellations are not *natural* groupings. Rather, they are groupings developed by human beings as a matter of convenience and interest.

### 5. THE EARTH REVOLVES AROUND THE SUN ON AN AXIS TILTED WITH REFERENCE TO THE PLANE OF THE EARTH'S REVOLUTION AROUND THE SUN

Children at this class level already know that the earth is one of the planets of the sun. They realize that the earth, like every other planet, goes in an orbit around the sun. This major concept concerns the details of the orbit and the earth's position in it. As children learn about the details, they will be able to understand better the relationship between the earth, its orbit about the sun, and the yearly cycle of seasons.

Some of these materials are touched upon in Unit 2, "Air, Water and Weather." They are mentioned both at the class III and class IV levels. It may be possible to integrate that approach with this unit, "Our Universe".

#### 5(a). THE EARTH COMPLETES ONE REVOLUTION AROUND THE SUN IN ONE YEAR

Each planet of the solar system proceeds around the sun in a definite orbit of its own. The earth, like most other planets, has an orbit which is almost a perfect circle. Each planet has a specific time required for completing one trip around its orbit. In the case of the earth, the period for one complete trip is exactly one year. Here are some activities which will help students understand this concept.

**Investigation**

### What is a planet's orbit?

Arrange for one student to stand motionless in the centre of the school room floor or in an open place outside. Have another child walk around him in a circle, as in Fig. 1-35. The student who walks should do so at an even speed. Let him try, for example, to make one complete trip around the other students while the class counts 10. In this case the 'year' for the walking student will be '10 counts'.

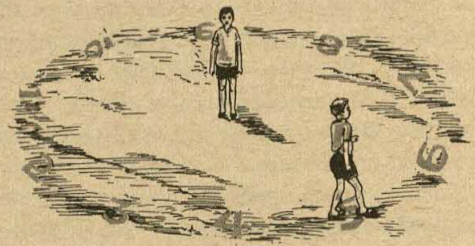


Fig. 1-35
In this illustration a year is '10 counts' long.

**Investigation**

### What is the plane of a planet's orbit?

*Materials required*
string

Let a boy hold one end of a string in his hand, while a girl holds the other end. While the boy stands still, let the girl walk around him. This is to be done on open ground. There will be round mark traced on the ground all round the boy, as in Fig. 1-36. The boy represents the sun, the girl represents the earth. The round mark corresponds to the path of the earth's motion i.e. the *orbit*. In this model, the line of orbit is on a plane surface i.e. the ground; the ground is the plane of the earth's orbit. The sun is in that plane, nearly in the centre of the orbit.

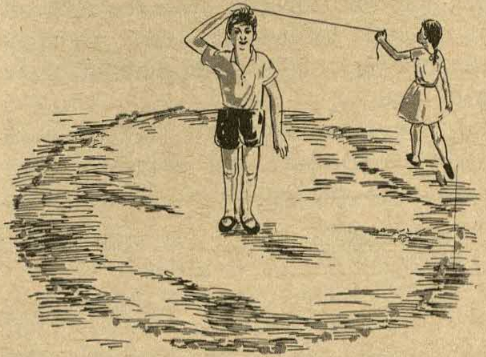


Fig. 1-36
The plane of a planet's orbit is the flat surface in which the orbit lies.

*Point out that for the earth, one year is not an integral number of days. It is not* 365 *days, nor* 365-1/4 *days. A year is actually a little less than the latter figure.*

### For Better Understanding

Ancient civilizations in many parts of the world knew the length of the earth year very precisely—often to within less than one minute of the modern accepted value. How did they arrive at their accurate values for the duration of year?

These ancient people thought the sun revolved around the earth. As the sun appears to go around the earth, it appears to move through the stars. Although the stars near the sun cannot be seen in the day-time they can be seen just at sunrise or sunset. Therefore, it is possible for observers to know in what constellation the sun lies at any time of the year. By observing this very carefully, early observers arrived at the concept that the sun seems to travel around the earth once in a little less than 365-1/4 days. This coincides precisely with the cycle of the seasons. In this way, early scientists estimated very accurately the duration of the year.

**5(b).** THE AXIS OF THE EARTH IS TILTED WITH REFERENCE TO THE PLANE OF THE EARTH'S REVOLUTION AROUND THE SUN

The earth has two kinds of motion with respect to the sun. One is called *revolution;* this is the annual trip of the earth in its orbit around the sun. In addition, the earth turns upon an axis which goes from the north to the south geographic pole. That is, it spins much as a top spins. This kind of motion is called *rotation*. The earth rotates on its' axis once each 24 hours. It is the motion of rotation which produces day and night.

It is important to realize that the relation between the earth's axis and the plane of the earth's orbit is not a simple one. A simple relation would exist if the earth's axis were perpendicular to the plane of the earth's orbit. Actually the axis is tilted at an angle of 23-1/2° from the perpendicular. It is the tilt of the axis which helps produce the annual pattern of seasons. Activities such as these can help students understand the relation of the earth's axis to the plane of its orbit.

**Investigation**

**What is meant by the tilt of the earth's axis?**

*Materials required*
string, football,
stiff wire, small rubber ball, wood peg

Select a piece of level ground, fix a peg at the centre of this space. Tie one end of a string a few metres long to the peg and the other end to a hard piece of wood. Trace a circle round the peg with this piece of wood. Remove the peg; place a football at the position of the peg; place a small rubber ball somewhere on the circular line.

Now, as shown in Fig. 1-37, the

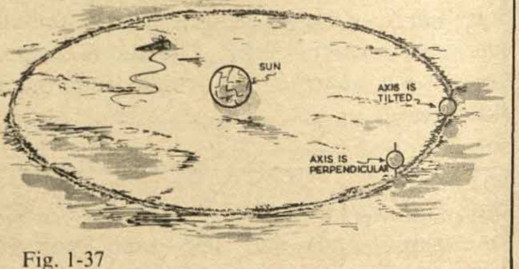


Fig. 1-37
The lower ball is placed with its axis perpendicular to the plane of the earth's orbit. The ball at right has its axis tilted as does the earth.

football represents the sun, the ball represents the earth and the circle scratched in the soil represents orbit.

Take a piece of strong wire, about 8 inches long, pierce holes in the ball exactly opposite to each other; insert the wire through the holes so that equal lengths are kept out at both ends. This wire represents the earth's axis.

Now insert one end of the wire into the ground so that it stands erect, perpendicular to the ground. This axis is now perpendicular to the plane of the orbit. Finally, insert the wire into the ground so that it is not perpendicular; now the axis is tilted with respect to the plane of the orbit.

*Use a protractor to find how big is the angle* 23-1/2°. *Mount a model earth with a visible axis in such a way that its axis is* 23-1/2° *away from the vertical. Point out that this is the degree by which the earth's axis is tilted with respect to the orbit.*

### For Better Understanding

The axis of the earth, if extended a great distance through the north pole, points almost exactly to a fairly bright star. This star is called the *Pole Star*, or *Polaris*. It corresponds to the end of the tail of the little Bear (Ursa Minor). Polaris is not precisely along the line of the earth's axis, but it is very close to that position. It has not always been so. Over an interval of some 26,000 years the earth's axis describes a giant circle through the sky. An observer of 2,000 years ago would not have used Polaris as the Pole Star. For the last few hundred years, however, and the next few hundred, Polaris is very close to being in line with the earth's axis. There is no bright star close to the southern extension of the earth's axis. That is, there is no Southern Pole Star.

**5(c).** SEASONS ARE CAUSED BY THE REVOLUTION OF THE EARTH AROUND THE SUN WITH ITS AXIS INCLINED TO THE PLANE OF ITS REVOLUTION

The fact that the earth's axis is not perpendicular to the plane of its orbit has extremely important results. The earth's axis is tilted in such a way that the north end of it points almost exactly towards the North Star. This means that as the earth makes its yearly orbit around the sun, the axis points sometimes towards the sun and sometimes away from it. When the earth's northern hemisphere is inclined towards the sun, the sun's rays are more direct on the north half of the earth. Furthermore, there are more hours of daylight than of darkness in the northern hemisphere. On the other hand, when the earth's northern hemisphere is tilted away from the sun, the sun's rays are more slanting; there are also fewer hours of daylight than there are of darkness. These two factors combine to produce the cycle of the seasons.

These two ideas—variation in the angle of the sun's rays and variation in the length of daylight—are also taken up in class IV of

Unit 2, "Air, Water, and Weather". Learning activities related to these ideas are in that unit, on pages 177 to 220 of this teacher's handbook. Some teachers may wish to combine closely related portions of Unit 2 and Unit 1.

**For Better Understanding**

The complete cycle of seasons takes exactly one year. The longest day of the year is 21 June. This is also the day when the sun's rays are most nearly overhead in the northern hemisphere. On this day, the sun stops its northward journey and slowly begins to move southward again. This day is called the *summer solstice*. Solstice means 'stationary sun'. Three months later, on 22 September, days and nights are of equal length. This is because the earth's axis is tilted neither towards nor away from the sun. This time of the year is called the *autumn equinox*. This name refers to the fact that days and nights are then of equal length.

December 22 is the shortest day of the year. Then the earth's northern hemisphere tilts away from the sun. This time of the year is known as the *winter solstice*. It is on this day that the sun stops moving farther and farther south and begins to return north. It is the time when the sun's rays strike at a most slanting angle in the northern hemisphere. On 21 March—the *spring equinox*—the length of day and night is again equal.

In the southern hemisphere the seasons are reversed from those in the northern hemisphere. When it is winter in the northern hemisphere, it is summer in the southern hemisphere. In south Africa, South America and in Australia it is warmest during December, January, and Ferbruary and coldest in June, July, and August. Therefore, they call the June, July, and August period 'winter' while the months of January, February and March are thought of as 'summer' months.

**5(d).** SUNLIGHT RECEIVED BY THE EARTH IN PLACES NEAR THE EQUATOR DOES NOT VARY MUCH THROUGHOUT THE YEAR

At the equator the sun always appears to rise in the east and set in the west. On 21 March and again on 22 September, the sun rises vertically in the east, passes directly overhead and descends vertically in the west. These two days then are the days of most intense solar radiation at the equator. On 21 June, the sun at the equator rises in the east and then swings into the northern sky. At mid-day it is well north of the zenith. It then descends and sets in the west. On 22 December, the sun at the equator rises in the east, then swings into the southern part of the sky. At noon it is well south of the zenith. Then it descends and sets in the west. Thus, although there are variations of the directness of the sun's rays at the equator, they are not nearly as significant as those in the medium north and medium south latitudes. Here are activities which can help students understand this relationship.

| **Investigation** | **What is the sun's path as seen from the equator?** | *Materials required*<br>light source, large ball or round earthen jug, clay |
|---|---|---|

Use a torch or a petromax lantern as a source of light to represent the sun. Use a large round ball or a large round earthen jug to represent the earth. Mount a stick with clay to indicate the location of the north geographic pole. Draw an equator on the model earth. Arrange the model earth with respect to the model sun so that the tilted axis points neither towards nor away from the sun, as in Fig 1-38. Have children observe that when the earth is in this position, the sun at the equator appears to rise in the east and set in the west. The same is true for any position of the earth throughout the year. At all times of the year the duration of daylight is 12 hours and duration of darkness is 12 hours *at the equator*. Help children see that at the times of spring and autumn equinox, the sun appears directly overhead at mid-day as seen from the equator. Challenge them to show where the equatorical sun appears to be overhead at mid-day in December, or mid-day in June. Help the class write letters as a group to a class at the southern tip of our country. Through this communication try to find out what seasonal conditions are like a few degrees north of the equator.

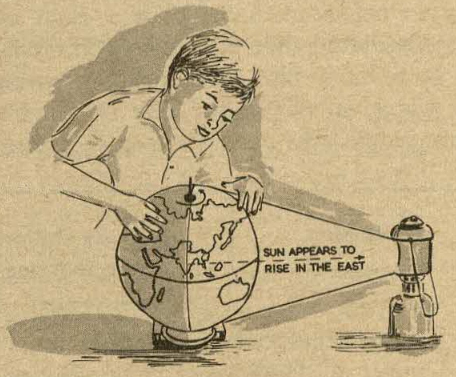

SUN APPEARS TO RISE IN THE EAST

Fig. 1-38
In March and in September the sun rises in the east and sets in the west.

## 6. CHANGES IN SEASONS AFFECT THE LIVES OF PEOPLE, PLANTS AND ANIMALS

As the seasons change, people generally change their mode of living. They have changes in their clothing, diet, amusements, and social activities. They feel energetic in winter; the summer heat makes them tired; their dressing methods are changed. They are forced to change their ways of life in many ways.

In the plant kingdom, old plants die out; new varieties grow up; there are changes in fruits, flowers, and leaves; some plants disappear, and others spring into life. Animals also change their habits with the changing seasons. The sub-concepts which follow are intended to focus children's attention on the effects of seasonal changes.

### 6(a). PEOPLE USE DIFFERENT CLOTHES IN DIFFERENT SEASONS

Clothes are used to protect the wearer against extreme outside temperatures. In addition, clothes provide protection, and they help keep the body clean. They should have a pleasing appearance.

The function of clothing in protecting the wearer against heat and cold is based on scientific principles. Heat can be conducted through all substances. Some substances are good conductors of heat, while others are poor conductors. Practically all varieties of cloth are poor heat conductors; that is, they are insulators. Some kinds of cloth are better insulators than others. A good insulator keeps body heat from escaping during the winter. In the intense heat of summer many people wear clothes whose good insulation keeps the outside heat away from their bodies. Here are some activities which can help students understand the part that good insulation plays in keeping people warm in winter and cool in summer.

**Discussion**

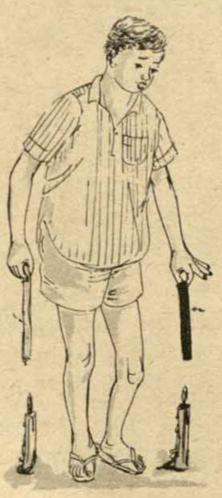
### How do clothes protect us from temperature extremes?

Ask students how they keep a container of food warm while they are carrying it to a worker in the cool winter. (They wrap it in a loose cloth). How do they keep from getting burned when they lift a hot cooking pan from the stove? (They use cloth as an insulator). Now turn their attention to cloth used as clothing. It is easy for students to see how the insulating properties of cloth keep them warm in winter. Ask them to provide examples of using cloth to keep cool in summer. (Persons taking an afternoon nap in the hot sun often cover themselves completely with a heavy cloth. Some farmers and other outdoor workers use a large turban of loosely wound cloth to keep their heads cool while they work in the hot sun).

**Investigation**

### Do materials differ in their ability to conduct heat?

*Materials required*
source of heat, metal strip or wire, cloth strip or string



Use a piece of wire net and a piece of cloth of the same size, as suggested in Fig. 1-39. Place one end of each as near to a flame as possible without setting the cloth afire. Which gets warm sooner, the other end of the metal or the other end of the cloth? Which material is the better conductor of heat? Which is the better insulator?

Fig. 1-39
Metal conducts heat better than cloth; cloth is a better insulator against heat.

**Investigation**

**How can we keep hot things hot and cool things cool?**

*Materials required*
two empty tin cans,
hot and cold water,
cloth

Prepare two identical cans of hot water. Wrap one loosely in cloth and leave the other bare. Place both cans in a cool place out of direct sunshine. Feel them both after an hour or so. Which one has remained the warmer? Why? Repeat with two identical cans of cold water. Place them in a warm place but not in direct sunlight. Which one remains the cooler after setting for an hour or two? Can insulation keep things cool as well as warm? Is there any difference in the principle involved in keeping things warm and in keeping things cool? What does this investigation have to do with clothing?

*On an extremely hot day, have some children play in direct sunlight bare-headed. Have others protect their heads with loosely tied turbans. Let them compare how comfortable they are.*

### 6(b). PEOPLE USE DIFFERENT DEVICES TO KEEP THEIR HOMES WARM IN WINTER AND COOL IN SUMMER

Among other things, a house is meant to protect people from the weather. Normal warmth and coolness are enjoyable; one generally desires to keep out in open at such time. But when it is very hot or very cold, one goes inside a building if he can. Buildings are usually arranged to keep out intense heat or cold. A house or a home is such a building.

In building a good house, care should be taken to arrange the building so as to keep heat in during the winter, and to keep heat out during the summer.

That is done by constructing the house of material which is a poor conductor of heat. The material used for the roof should also be a poor heat conductor. Execellent building materials for this purpose are wood for walls and thatch for roofing. Mud and stone walls are quite good for insulation, and they are usually much cheaper than wood. Metal, on the other hand, is a very poor insulator for heat. Here are some activities which will help students understand the uses of insulating materials in houses and other buildings.

**Discussion**

**What are the common materials used in building houses?**

Invite students to say what materials are used to make the buildings in their community. Materials mentioned will include mud, stone, cloth (tents), brick, wood, metal, and others. Ask them which materials provide the coolest places in summer, the warmest in winter.

**Investigation**

### How well do different materials protect against extreme heat?

*Materials required*
metal box, wood or cardboard box of the same size

Secure a metal box and a wood or cardboard box of about the same size and colour. Place them open-side down out in the hot sun. After about half an hour, have children place their hands under each box to compare the temperatures, as in Fig. 1-40. Which material has provided the better insulation against the intense heat?

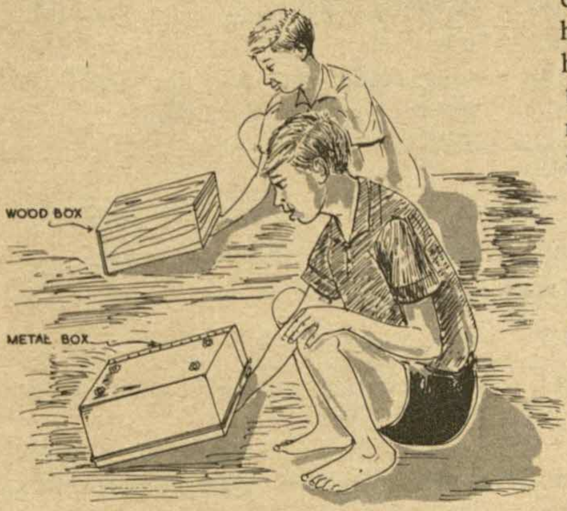


Fig. 1-40
Wood provides better insulation than does metal.

*On a very hot afternoon, challenge children to find the coolest indoor place they can. It will probably be in a room on the shady side of wood or mud and stone building.*

### 6(c). THE BEHAVIOUR OF PLANTS AND ANIMALS VARIES FROM SEASON TO SEASON

Plants and animals are strongly affected by the seasons—often more so than people are. For crops, there is a planting season, a growing season, and a season for harvest. Plants bear their flowers at certain seasons of the year, grow their fruits somewhat later. Many trees shed their leaves just before spring. The timing of these functions is different for different plants, of course.

Animals too have different behaviours at different times of the year. At a certain season animals mate, and at another season young animals are born. Fur-bearing animals shed their heavy coat as the season grows warmer. Some animals migrate at specific times of the year. Here are some activities which can help students appreciate the great extent to which plants and animals are influenced by changes in seasons.

**Class Project**

**What food-growing activities take place in various seasons?**

Organize the class into a few work-committees. Let each committee select one kind of food crop, such as fruit or nuts or pulses or grains. Help each group prepare a chart indicating for their food crop what activities occur during various months of the year. Have each group explain their findings to the rest of the class. Help all students realize how closely the raising of food crops is related to the cycle of the seasons.

**Discussion**

**How do living habits change with the seasons?**

Let students describe how they live, what food they eat in different seasons, how they change their dress, etc. Discuss with them the effects of seasonal change on animals, including forest mammals, birds, fish, and insects.

Let them describe the changes which take place in flowers, fruits, and leaves of trees. Help them make a list or a chart of these differences.

*Make and compare lists of birds to be seen in summer and those to be seen in winter. Do likewise for insects, small animals, flowers and food plants.*

# UNIT 1

# OUR UNIVERSE

## CLASS V

### Overview

This is the last stage of primary school students learning about the universe, its contents, and its motions. The more they explore the causes of the effect they observe, the more they learn about the complex patterns of change.

The subject matter here in class V relates to the moon. To begin with, attention is drawn to the character of the moon itself—its shape, its size, and its surface conditions. The efforts of many nations' scientists to learn more about the moon through space travel provide excellent motivation here, as well as exciting sources of information.

Also included here are the cause-and-effect relations between the sun, the moon, and the earth and the pattern of tides. Children learn that the gravitational effects of bodies extend beyond the surface of the objects themselves—sometimes for many millions of miles. Thus they get an introduction to the law of universal gravitation. In this connection, students see clearly that some of the natural laws which apply on the earth also apply in the near-empty spaces of the solar system. The 'universal' in 'law of universal gravitation' is emphasized.

In utilizing the principle of cause and effect, students have a chance to learn something about certain superstitions with which they are already acquainted. They can understand the relation (a gravitational one) between the moon and tides. However, there seems to be no such relation between the position of the moon and the time of planting the fields. They learn the causes of lunar and solar eclipses, but they can see that such events have no explainable effect on the lives of people. In a similar way, children can be encouraged to doubt the existence of any effect of the position of the planets on their own lives, their good and ill fortunes or their future. Well-guided learning experiences of this kind can help produce a generation of young adults who are more likely than their parents to make decisions on the basis of evidence, cause-and-effect relationships, and rational thinking and less on superstition, the advice of fortune-tellers, and emotions.

### 1. THE MOON IS A BARREN, LIFELESS BALL

The moon is a sphere. Its diameter is almost 3500 kilometres. It is a little more than one-fourth the size of the earth. In many ways the earth and the moon might be considered as a pair of sister planets, each revolving around the other. One of the pair, the earth, is four times the diameter of the other one, the moon.

Now that the moon is being studied more and more carefully through space vehicles, it becomes increasingly interesting to children. At this class level, it is appropriate to study the moon as an object in the solar system, as well as its effects on the earth.

**1(a).** THE MOON HAS NO AIR OR WATER; NO LIVING THINGS EXIST ON THE MOON

There is no substantial evidence that the moon has any atmosphere. Stars seen near the edge of the moon show no blurring as they would if an atmosphere were present. No clouds are seen on the moon even through the most powerful telescope. There is no evidence of any erosion by water. Unlike Mars, there is no evidence of ice or of clouds or of dust. Careful calculations show that the mass of the moon is too small to prevent an atmosphere from escaping. All evidence indicates that the moon is without any atmosphere and without any water. Living things in the earthly sense of the word could not exist on the moon. Here are some activities which can help children better appreciate conditions on the moon.

**Discussion**

**What is it like on the moon?**

Invite children to discuss what it would be like if there were no atmosphere on the earth. Of course, human beings and other living things could not exist. Without an atmosphere, there would be no weather and, therefore, no rain. With no rain, there would be no erosion. With no air, there would be no sound. Challenge students to imagine other kinds of conditions which would exist on the moon with no atmosphere.

*If a simple telescope or field glass is available, permit children to look at the full moon or nearly full moon through it. When seen even under slight magnification, the moon does indeed look like a ball, rather than a flat disc in the sky.*

**1 (b).** THE MOON'S SURFACE INCLUDES MOUNTAINS, CRATERS AND FLAT PLAINS

Any one looking at the moon sees a surface which is partly very bright and partly dim. People often refer to 'the man in the moon' as they imagine a face made up of the dark and light areas of the moon. Careful inspection through telescope shows that the dark areas are broad flat plains, while the lighter areas are ranges of mountains and craters. Evidently the mountain ranges reflect more light than do the broad flat plains. Activities such as those which follow will help children better understand this unusual appearance of the moon.

**Familiar Experience**

**Do hills sometimes look brighter than flat fields?**

Ask children to recall some condition—such as that of early morning or late evening—when nearby hills have more light on them than the flat fields. Evidently conditions on the moon are something like this. On the moon the mountains reflect more light than the flat plains do.

*If a low-power telescope or a field glass is available, permit students to look at the moon through it. Even with low magnification, the bright areas of the moon can be seen as mountains and craters.*

## For Better Understanding

Before the development of the telescope in 1609, it was commonly thought that the surface of the moon had great oceans or seas upon it. Ancient scholars thought that the dark areas were the oceans. These were given names such as the 'Sea of Showers' and the 'Sea of Nectar'. Once the telescope was turned towards the moon, however, it was seen that these were not vast bodies of water, but large flat plains of darker coloured material than those which made up the mountains.

The moon always keeps the same face towards the earth. No one has ever directly seen the 'backside' of the moon, since it is always away from the earth. The moon has day and night, something the way the earth does. However, a day and a night on the moon require almost 30 earth days. As a result, any one spot can get very hot during a 'daylight' of nearly 15 days. Later during a 'night-time' of nearly 15 days that spot on the moon becomes extremely cold.

Because the moon is so much smaller than the earth, it exerts a smaller force of gravity on objects at its surface. If a given object were taken from the earth to the moon, its weight there would be about 1/6th its weight on the earth.

**Scientists at Work**

**Galileo develops the telescope**

Have you ever looked through a telescope—even a simple one? Have you enjoyed seeing how it makes small things look large and how it makes distant objects appear close? How fine these telescopes are for making observations of the moon and the planets and the stars!

Yet scientists did not always have these telescopes to help them in their study of astronomy. Indeed, the first telescope was made scarcely three and a half centuries ago. And here is a strange thing about the telescope—no one seems to know for sure who made the very first one.

What is known is that in 1609, the great Italian scientist, Galileo, received a letter which gave him an idea. In the letter he read that a lens-maker from Holland had developed a simple device which made distant objects look closer and also upside down. The device was described as being an arrangement of two lenses. According to some stories, this had been accidentally discovered by the lens-maker's children while they were playing with their father's lenses. Anyhow, it gave Galileo an idea.

Galileo was a very brilliant man. He knew a lot more about light and lenses than the Dutch lens-maker did. So it was natural that he should figure out how the new device worked, and to improve upon it. Galileo made several of these simple telescopes. His instruments made things seem as much as thirty times closer; furthermore, they did not turn the image upside down. So although Galileo did not make the first telescope in the world, he did take the idea of a simple toy-like device and develop it into a highly useful scientific instrument.

Another thing that Galileo did was to use his telescope for scientific purposes. Before his time, the simple telescopes were used merely as novelties or toys. But Galileo was very curious about the moon and the sun and the planets and the stars. So one of the first things he did was to turn his telescope towards the skies. He was the first to see that the moon had mountains and craters, and that the 'seas' were really dark, dry plains. He was the first to see spots on the sun. This was a great surprise to scholars, for they thought the sun was 'perfect' and, therefore, without any marks on it. Most people at that time also thought that all heavenly objects revolved around the earth, and that nothing could possibly revolve around any other object. But Galileo observed four moons or satellites revolving around Jupiter. Galileo used these kinds of information to argue that the sun, not the earth, was the centre of the universe.

Today scientists have huge telescopes which see millions of light years into space. The largest of these telescopes is in the United States. Its giant mirror (which is used instead of one of the lenses) is just over five metres in diameter. Scientists also use many other kinds of special instruments to help them explore the space beyond the earth. Modern scientists use some of the most exciting special instruments of all—the vehicles of space travel. Already space-probes filled with scientific instruments have explored and photographed the moon, Venus, and Mars. Within a few years scientists will be able to land human observers on the surface of the moon.

These are all examples of the way man extends the abilities of his eyes by using scientific instruments. In the field of exploring space, Galileo took the first big step. Would he not be surprised to see the steps that scientists are taking today? And who knows what other steps will be taken in the years yet to come?

## 2. TIDES ARE CAUSED BY THE GRAVITATIONAL ATTRACTION OF THE MOON AND THE SUN ON THE EARTH AND ITS OCEANS

People who live near the ocean are well aware of the cycle of the tides. Although patterns of tides vary widely from place to place on the earth, it is common to have a high tide about every 12-1/2 hours. In some places these tides make the water go up and down less than one metre. In other places the difference between a low tide and a high tide may be 15 metres or even more.

### 2 (a). THE TIDE-PRODUCING EFFECT OF THE SUN IS LESS THAN THAT OF THE MOON

Because of the principle of gravitation, all objects in the solar system exert forces on each other. In many cases objects are relatively small and distances are relatively great. Under these conditions the gravitational attraction may be too small to measure. However, the moon is very close to the earth and exerts considerable gravitational force on it. Although the sun is much farther away than the moon, it has tremendously greater mass than the moon. As a result, the distant sun exerts more gravitational force on the earth than does the moon. In spite of this, the effect of the *sun on tides* is less than that of the *moon on tides*. (See also "For Better Understanding" following these activities). Here are some activities which can help make this difficult situation clear to children.

**Discussion**

**How does the distance to an object influence its tide-producing effect?**

Help students make a simple scale drawing of the earth and the moon, something like that in Fig. 1-41. Recall

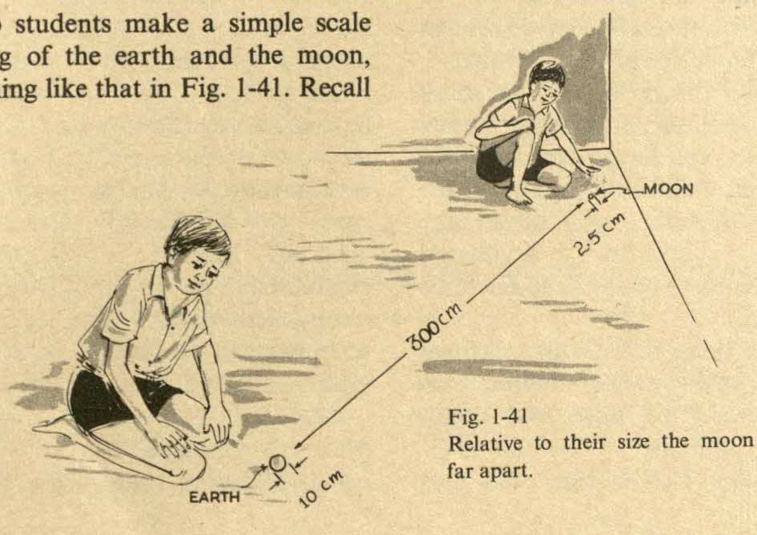


Fig. 1-41
Relative to their size the moon and earth are far apart.

that the moon is about 30 earth-diameters away from the earth. That means that the point of the earth away from the moon is about one part in thirty farther away than the point on the earth closest to the moon. This relationship—*one part in thirty farther away*—is important to keep in mind.

A similar scale drawing can be made of the earth in relation to the sun. Students can find that the point on the earth farthest from the sun is only about one part in twelve thousand farther away than the point on the earth nearest to the sun. Help children realize that with respect to the sun all parts of the earth are *nearly the same distance.* In contrast to this, all parts of the earth are not nearly the same distance from the moon.

*Allow a student to whisper into one ear of another student. Can the listening student tell the difference in the intensity of sound between the ear close to the whisperer and the ear which is far from the whisperer? Let the same experiment be done when the two students are separated by several metres. Discuss the relationship of this activity with that of the tide-producing effect of the nearby moon and the more distant sun.*

### For Better Understanding

Most people do not understand the comparison between the tide-producing effects of the moon and the tide-producing effects of the sun. The effect of the sun's gravitational field is about 150 times as great as the effect of the moon's gravitational field. It is also true that the moon produces tides more than twice as effective as those of the sun. How these two statements can both be true is a mystery to many people.

The key to understanding this confusing situation lies in the comparison of distances from the moon to the near side and far side of the earth. The far side of the earth is about one part in thirty farther from the moon than is the near side of the earth. Therefore, the *difference* in the moon's gravitational effect between the near side and far side of the earth is substantial. On the other hand, the far side of the earth is only one part in twelve thousand farther from the sun than is the near side of the earth. As a result, the *difference* in the sun's gravitational force on the near and far side of the earth is far less than that of the moon.

Many class V children will have trouble in understanding this difficult point. So will many adults. It is not essential that the fine points of gravitational theory be understood by students at this class level. Children may be given incomplete information, so long as it is accurate.

### 2(b). THE MOON'S GRAVITY PRODUCES A HIGH TIDE ON THE SIDE OF THE EARTH TOWARDS THE MOON

The surface of the earth is closer to the moon than the centre of the earth. As a result, the moon's gravity is more effective on the near side of the earth than it is on the centre of the earth. Actually, the moon's gravity does cause the earth itself bulge a little bit. For the most part, however, this difference in gravitational force effects only the water of the earth. The result is that the water of the earth rises on the side towards the moon. Here are some activities which can help children understand this sub-concept.

**Discussion**

**How does the moon produce a high tide of the waters nearest to it?**

Prepare a drawing something like that in Fig. 1-42. Notice that the water on the near side of the earth is drawn as though it is separate from the solid part of the earth beneath it. Now add the moon to the sketch. Help children realize that the gravitational force of the moon attracts the water which is closer to the moon more than it does the central part of the earth which is farther from the moon.

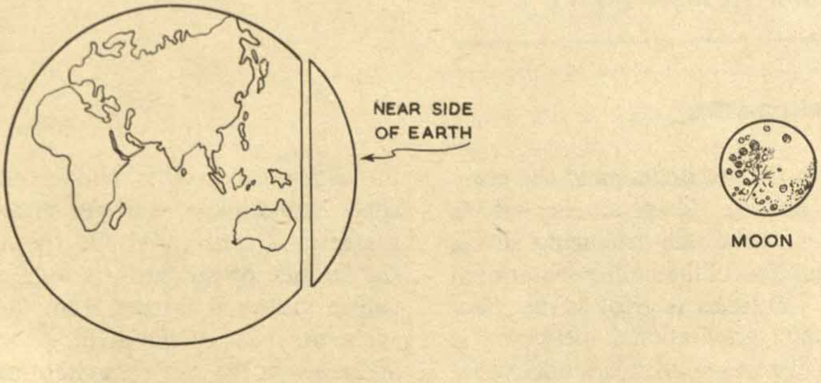


Fig. 1-42
Gravitational pull of the moon attracts most directly the waters on the near side of the earth.

*Help children compare the distance from the surface of the earth to the moon (about* 373,500 *kilometres) with the distance of the centre of the earth from the moon (about* 380,000 *kilometres).*

**2(c).** THERE IS A HIGH TIDE PRODUCED ON THE SIDE OF THE EARTH AWAY FROM THE MOON

In the sub-concept above, it was pointed out how the moon attracts the near surface of the earth more than it does the earth's centre. In a similar way, the moon attracts the earth's centre more than it does the far side of the earth. Here is an activity to help make this clear to children.

**Discussion**

**How does the moon produce a high tide of the waters farthest from it?**

Prepare a sketch like that in Fig. 1-43. Illustrate two sections of oceans as though they were separate from the solid part of the earth beneath. Now add the moon to the sketch. To review the previous sub-concept, show the ocean nearest the moon being pulled towards the moon by, say, three centimetres. Now show the centre of the earth as being moved two centimetres towards the moon. The part of the occean away from the moon is moved one centimetre towards the moon. Help children see that the difference in gravitational pull of the moon between the near side and far side actually produces a bulge in the water on *both* sides.

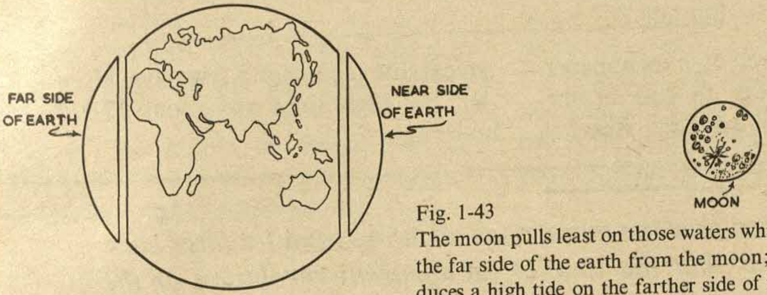


Fig. 1-43
The moon pulls least on those waters which are on the far side of the earth from the moon; this produces a high tide on the farther side of the earth.

*Help children compare the distance from the moon to the centre of the earth (about* 380,000 *kilometres) with the distance from the moon to the far side of the earth (about* 386,500 *kilometres).*

**For Better Understanding**

The explanations of the tides involved in the foregoing activities are extreme simplifications. The earth, of course, is not divided into three separate sections. Furthermore, it is not correct to think of the tides as being caused by the 'stretching' of the waters of the earth. What really happens is that the earth itself does stretch a little bit (perhaps as much as few metres). But there are still unbalanced forces on the waters of the earth. The water is free to move. So, as a result of the moon's gravitational force, water actually *flows* from some parts of the ocean to other parts. In Fig. 1-43, the water flows away from the parts of the earth at the top-centre and bottom-centre of the diagram. It flows towards the left and right parts of the diagram of the earth.

People who live near the sea coast are well aware that tides produce more than just a change of depth of water. They see tidal *currents* of water. Sometimes these currents are severe enough to be dangerous to ships which are operating in harbours or bays.

**2 (d).** THERE IS A HIGH TIDE ABOUT EVERY 12-1/2 HOURS

The sub-concepts above have outlined how it is that at any moment there are high tides on opposite of the earth. Since these are the results of moon's gravitational pull, it is natural to expect that this pair of high tides follows the moon in its motion around the earth. The moon seems to go around the earth once in about 24 hours and 48 minutes. Accordingly, there are high tides about twice that frequently. Children can be helped to understand this relationship through the following activities.

**Class Project**

**What is it like to live where there are tides?**

Write to a school or a newspaper or a weather bureau in one of the coastal cities of our country. Ask for typical tide tables for a few days. Note that the high tides are about 12-1/2 hours apart.

*Remind children that the moon rises about* 48 *minutes later each night. This means that the time of an apparent revolution of the moon around the earth is* 24 *hours and* 48 *minutes. Compare this with the time between the high tides.*

**For Better Understanding**

There are many other factors besides the moon which determine the tides of the oceans. Although the sun's effect on tides is less than that of the moon, it still helps determine tides to some extent. When the sun's gravitational force is in the same direction as the moon's, the tides are greater. These are called 'spring' tides. However, when the sun, the moon and the earth are not in a straight line, the tide-producing effects tend to cancel each other. The result is tides of lower magnitude. These are called 'neap' tides.

The shape of the shore line of the ocean and the depth of the ocean at any point also affect the tides. Furthermore, the inertia of water is such that the actual existence of high tides is delayed by many minutes or even a few hours behind the time when the moon is most nearly overhead.

There appears to be no formula for computing tides. In practice people in cities along the coast observe the tides and make tables and predictions on the basis of their observations. To a sailor in the middle of an ocean, there appear to be no tides. The water to him always seems to be at the same level.

### 3. AN ECLIPSE TAKES PLACE WHEN THE MOON AND THE EARTH ARE IN A DIRECT LINE WITH THE SUN

Scientists have known for many many hundreds of years how eclipses are caused. They have known that an eclipse of the moon is really caused by the earth stopping sunlight from reaching the moon. Similarly, they have realized that an eclipse of the sun occurs when the moon gets between the earth and the sun. The common people of long ago did not know this, and were extremely worried whenever there was an eclipse. However, scholarly people knew about it and were not worried when an eclipse occurred.

Even so, an eclipse of the sun or an eclipse of the moon is an interesting and awe-inspiring sight. Students will understand it better and appreciate it more as they know more and more about the details of the causes of eclipses.

#### 3(a). THE SHADOW OF THE EARTH PRODUCES A LUNAR ECLIPSE

The relative positions and movements of the earth and the moon with respect to the sun are such that the earth sometimes gets in a direct line between the sun and the moon. When this happens, the earth gets in the way of sunlight, that is, the earth's shadow falls on the moon. This produces an eclipse of the moon. Children can be helped to understand this through activities such as those which follow.

**Investigation**

**How is a lunar eclipse produced ?**

*Materials required*
light source, large ball or round earthen jug, small ball

Use a torch or a petromax lantern to serve as a model sun. Use a large round ball or a large round earthen jug as a model for the earth. For the moon use a ball about one fourth the diameter of that used for the model earth. Permit a student to move the ball until it is in the shadow of the earth, as in Fig. 1-44. This is a crude model of a lunar eclipse.

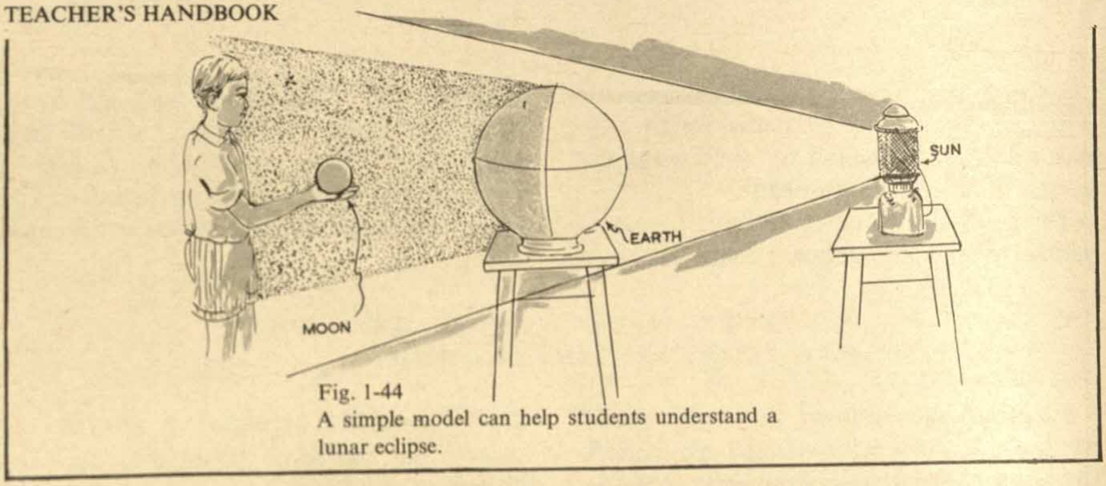


Fig. 1-44
A simple model can help students understand a lunar eclipse.

*On a sunny day, when the sun is close to the horizon in early morning or late evening, permit a child to walk around a small building. Usually he is in the sunlight. But occasionally he walks in the shadow of the small building. This is 'an eclipse of the child.'*

### For Better Understanding

During a total lunar eclipse, the moon appears to be there, but deep red in colour. This is produced by sunlight passing around the earth. As it passes through the atmosphere, the light bends somewhat so that it strikes the moon, as in Fig. 1-45. Also, as it passes through the atmosphere, much of the blue and green light is filtered out. Only the red and yellow parts of the sunlight get through. This is why the dimly-lit moon during a total lunar eclipse appears to have a deep red colour.

### 3 (b). THE SHADOW OF THE MOON PRODUCES A SOLAR ECLIPSE

The relative position and motion of the moon and the earth with respect to the sun are such that the moon sometimes comes directly between the earth and the sun. When this happens, the moon blocks some of the sunlight and the moon's shadow falls on the earth. This produces an eclipse of the sun. Activities such as those which follow can help children understand solar eclipse.

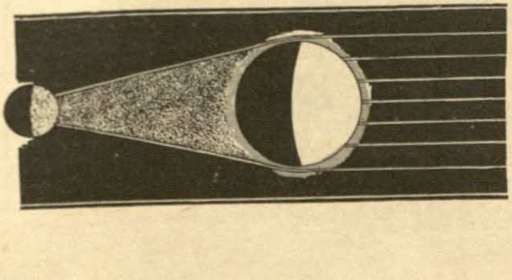


Fig. 1-45
The moon's red appearance during an eclipse is due to sunlight which has gone through the earth's atmosphere.

**Investigation**

## How is solar eclipse produced?

*Materials required*
light source,
round ball or
large earthen
jug, small ball

Use a torch or a petromax lantern as a model of the sun. Use a large round ball or a large round earthen jug as a model of the earth. Use a ball about one fourth as big as the earth-model for the moon. Allow a student to place the moon-model in such a position that it casts a shadow on the earth, as in Fig. 1-46. This is a model of a solar eclipse.

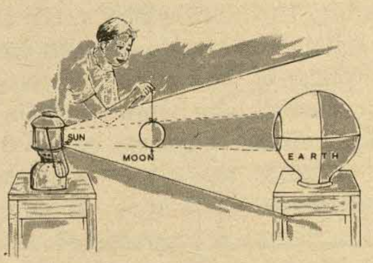


Fig. 1-46
The eclipse of the sun occurs when the moon blocks out the sun's light.

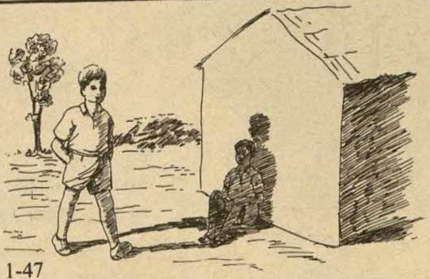


Fig. 1-47
In this illustration 'an eclipse of the sun' is seen by the student near the shack.

*Select an hour early in the morning or late in the evening when the sun is clear but low in the sky. Allow a student to walk around a small building. Usually his shadow falls on the ground. At certain positions, however, his shadow falls upon the building. To an observer at the building, this appears as an 'eclipse of the sun', as in Fig.* 1-47.

### For Better Understanding

A solar eclipse does not occur at all parts of the earth at once. Actually the moon's shadow on the earth is usually only a few miles across. This shadow may sweep along a path a thousand or two miles in length. A total eclipse of the sun is thus seen only by the few people who happen to be in this path a few miles wide and one or two thousand miles long.

**3(c).** SOMETIMES ECLIPSES ARE TOTAL; SOMETIMES THEY ARE PARTIAL

An eclipse of the moon is a total eclipse only when the earth's shadow covers the complete disc of the moon. Activities such as these will help students understand this fact.

**Investigation**

**How is a partial lunar eclipse produced?**

*Materials required*
light source, round ball or large earthen jug, small ball

Repeat the activity of Fig. 1-44. This time permit a student to hold the moon in such a position that it is partly in the shadow of the earth and partly in the sunlight. This is the condition of a partial lunar eclipse.

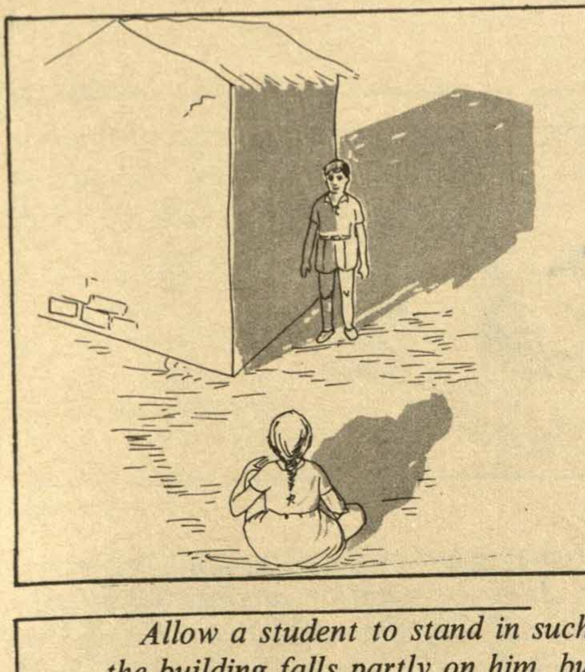


Fig. 1-48
To the crouching girl, the half lit student appears as 'a partial eclipse of the student' (moon).

*Allow a student to stand in such a position that the shadow of the building falls partly on him, but the rest of his body is in the sunlight, as in Fig.* 1-48. *To an observer, he will appear to be 'partially eclipsed.'*

An eclipse of the sun is a total eclipse for any observer only if the sun is completely blocked by the moon's disc. If the sun is only partially blocked by the moon, the result is a partial eclipse. Students can be helped to understand this through learning activities such as these.

**Investigation**

**How is a partial solar eclipse produced?**

*Materials required*
light source, large ball or round earthen jug, small ball

Repeat the investigation of Fig. 1-46. This time allow a student to place his finger on the earth at the edge of the moon's shadow. Ask him to predict what he would see if his eyes were at that point. Now let him put his eyes there and look towards the torch or petromax, the 'sun model'. He will see only part of the light source since the rest is blocked by the model of the moon. He is seeing a model of a partial solar eclipse.

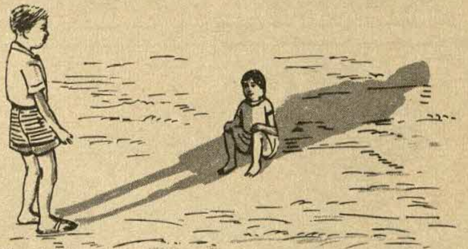


Fig. 1-49
The girl can see part of the sun; the rest is hidden by the shadow of the boy. To the girl this looks something like 'an eclipse of the sun'.

*Let a child stand in the sunlight. Another child can place his body in such a position that the edge of his shadow falls across the face of the first student, as in Fig. 1-49. The first student on looking towards the sun sees only part of the sun's rays. He is seeing a kind of partial solar eclipse.*

**For Better Understanding**

When there is a lunar eclipse, all the people on the side of the earth away from the sun see the lunar eclipse, and see it in the same way, provided there are no clouds. However, during a solar eclipse the appearance depends on where one is on the earth.

Only a tiny fraction of the earth's population sees a total eclipse on any one day. Another minority will see a partial eclipse. Usually, however, only a very small fraction of the total earth's population sees any direct evidence of the eclipse of the sun.

**3(d).** A LUNAR ECLIPSE OCCURS ONLY ON A FULL MOON NIGHT

All eclipses of the moon—whether total or partial—occur when the moon is precisely full. This is a matter of thousands of years of human observation. Activities such as these can help students realize why this relationship is true.

**Investigation**

**In what part of the lunar cycle does a lunar eclipse occur?**

*Materials required*
light source, large ball or round earthen jug, small ball

Reproduce the activity of Fig. 1-44. When the moon model is almost in the shadow of the earth, ask a student to view the moon from the position of the earth model. He will see that the moon appears at this time to be full. Challenge him to produce a model situation where there is an eclipse of the moon, but not a full moon. He will find that this is impossible.

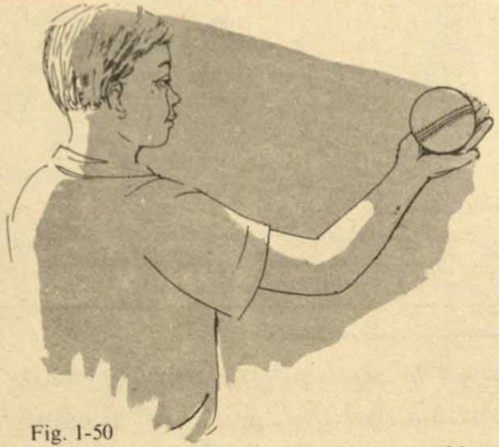


Fig. 1-50
To this student the shadow produces something like an 'eclipse of the ball' (moon).

*Let a student hold a ball in his outstretched hand in such a way that the ball is in the shadow of his own head. Fig. 1-50 suggests how the student finds that as the ball approaches this position, its sunlit side is entirely towards his head.*

### 3(e). A SOLAR ECLIPSE OCCURS ONLY ON A 'NO MOON DAY'

Whenever a solar eclipse occurs, the moon is completely invisible in the sky. During the few hours before or after the solar eclipse, the moon is too close to the sun to be seen. During the moments of the eclipse, only the dark side of the moon is towards the earth. Activities such as these can help children understand this relationship.

**Investigation**

**In what part of the lunar cycle does a solar eclipse occur?**

*Materials required*
light source, large ball or round earthen jug, small ball

Reproduce the investigation of Fig. 1-46. Help students realize that under the conditions of a solar eclipse, the bright side of the moon is away from the earth. Furthermore, the moon is in line or nearly in line with the sun. For these reasons the moon cannot be seen at or near the time of a solar eclipse. It is the time of 'no moon'.

*Allow a child to hold a ball in his hand in such a way that the shadow of the ball falls on his face. Help him realize that now the illuminated side of the ball is entirely away from him.*

### 3(f). ECLIPSES DO NOT OCCUR EVERY TIME THERE IS A FULL MOON OR 'NO MOON'

Once students understand the cause of the solar and lunar eclipses, they often fail to see why these eclipses do not occur more frequently. The fact is that the sun, the moon and the earth must be almost precisely in a straight line in order to produce an effect. For more often than not, the full moon misses the earth shadow or the shadow of the moon misses the earth. Activities such as those which follow can help children understand the relationship.

**Investigation**

**What can be learned from a scale of model earth-moon system?**

*Materials required*
4 cm ball, 1 cm ball, thread, light source

Obtain a ball or a model about 1 centimetre in diameter and another about 4 centimetres in diameter. These will serve for a model of the moon and a model of the earth respectively. To be in good scale relationship, they should be about 140 centimetres apart. Arrange to have a torch on a petromax lantern in a dark room to serve as a model of the sun. The sun model should be several metres away from both the earth and the moon models. Arrange the models so that the shadow of the moon falls on the earth, as in Fig. 1-51. Help students observe how precisely the models must be arranged in order for this to happen. In a similar way, position the moon and the earth models so that they produce a model solar eclipse. Again, observe how carefully these spheres must be placed in order to produce the effect. This should suggest to students why it is that eclipses do not occur every time there is a full moon or 'no moon'.

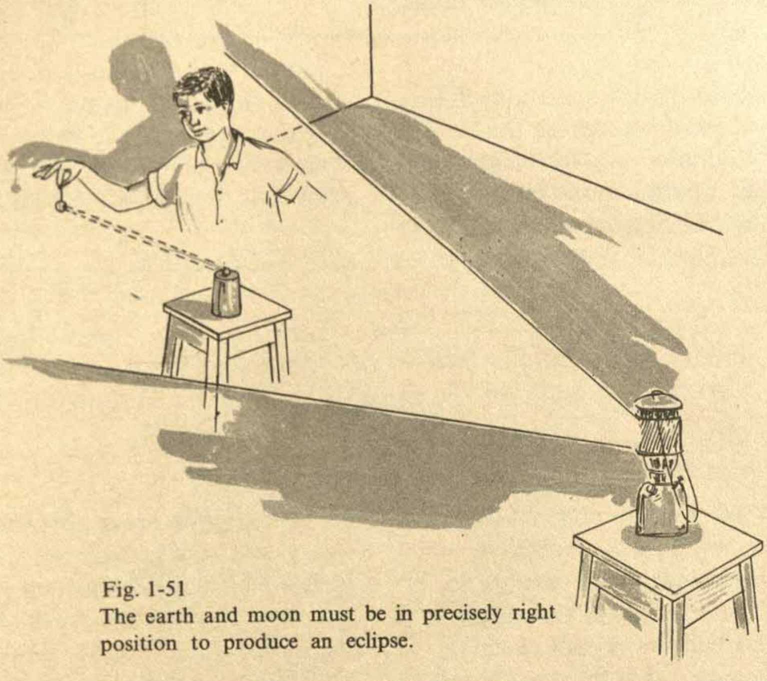


Fig. 1-51
The earth and moon must be in precisely right position to produce an eclipse.

*On a sunny day ask a student to throw a ball in such a way that the ball's shadow crosses a given spot on the ground. This will help him realize that the ball must be in just the right place to cast a shadow over a desired spot. In a similar way, the moon must be in just the right place to produce an eclipse.*

INSTITUTE OF EDUCATION FOR WOMEN
Dept. of Extension
SERVICE
CALCUTTA-27

# UNIT 2

# AIR, WATER AND WEATHER

## CLASS I

### Overview

Air, water and weather are so common and familiar that most people simply take them for granted. Young children sometimes even fail to recognize that air is anything but 'emptiness'. Yet man depends on air, water and weather in many ways, many times each day. Accordingly, these branches of science have a natural importance. Also, there is much enjoyment to be had from breezes and other actions of air and of water, and from the ceaseless changes of the weather. Therefore, these topics are not only important, but also very interesting. For these reasons, some organized study of air, water and weather should be included each year in the education of primary school children.

At class I level, children are introduced to the notion that air is *something*—a real, material substance. They also learn that air is found almost everywhere, and that air is necessary for man's existence. Similarly, they learn something of man's need for water. Finally, they see that weather changes constantly, from day to day, and even at various times of the day. They also begin to make conscious observations of the more common aspects of the weather.

Children at this level need not make a detailed, scientific study of air, water and weather. Rather, they should learn that these things exist, and that they are important and interesting. They should learn certain essentials of scientific vocabulary. Most important of all, they should practise a way of observing and experimenting—*a way of science*. This should be the main object of the teacher.

### 1. AIR IS EVERYWHERE

It is easy to show adults that air exists not only in atmosphere above the ground, but almost everywhere. There is air in the soil, in most foods, in clothing, in wood, and even in water. They are surprised to learn that air is in many other places as well. It is particularly surprising for them to find that there is air where it cannot be seen or even suspected. The sub-concepts below give some evidence of the fact that air exists in so many places. However, before children begin to find out the many places where air exists, they must become convinced that air *exists,* that it is not 'the absence of material' and that air is really something.

### 1(a). AIR IS SOMETHING

Most small children associate air with the *absence* of something, such as water; hence air is associated with nothingness. They do not realize that an 'empty' jar, for example, is really full of air, which is *something*.

When children inhale, they are taking air into their lungs. When they exhale, they are forcing air out. True, the exhaled air has been slightly modified in the lungs, but basically it is still *air*. This knowledge can give children a feeling of personal contact with the air with every breath they take. Children can be helped to accept the physical reality of air through first-hand experiences such as these:

**Investigation**

**Why do cheeks puff out?**

*Materials required*
small clean nut or ball

Invite children to puff out their cheeks by blowing, as in Fig. 2-1. Ask them what makes their cheeks stretch out like balls. Ask one child to place a clean nut or a small clean ball in his mouth, outside his teeth, where it makes a visible bump in the cheek as in the sketch. Discuss with children why the nut or the ball pushes the cheek out. Encourage them to say that something in the child's mouth *is pushing his cheek out*. Similarly, something must push the cheeks out when the children puff their cheeks. Help them realize that this 'something' is *air*.

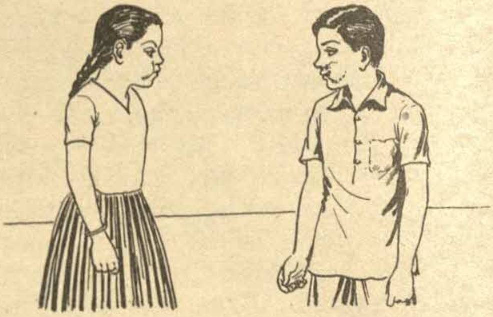


Fig. 2-1
One child's cheek is pushed out by air; the cheek of the other is pushed out by some solid object in the mouth.

**Investigation**

**How is a bag inflated?**

*Materials required*
balloons or paper bags

Help children inflate balloons or paper bags by blowing into them as shown in Fig. 2-2. Discuss with them the fact that something is pushing out from inside the balloon or the bag. But there is nothing inside but the breath—the air—which they have blown in. Help them realize that this air is the 'something' which inflates the balloon or the bag.

Fig. 2-2
Bags and sacks can be filled with air; air is surely *something*.

*Demonstrate a pinwheel turning as a child blows on it. Note that any explanation of how it works involves the notion that air (breath) is a material substance.*

*Repeat the above by holding the pinwheel in a breeze, then by moving it through still air.*

It is useful to draw children's attention to the function of air in tyres of bicycles and automobiles. When there is no air in a tyre, it is flat and useless. But when you force air into it with a tyre pump, the air exerts enough force to support a heavy load. When more and more air is pumped in, the air can support a heavier and heavier load. You can put so much air in the tyre that it will burst. So great is the force exerted by air that it would not be correct to consider it (air) as 'mere emptiness' or 'nothing at all'.

**For Better Understanding**

Actually, air is not a simple gas, but a mixture of gases. Most of the air—about four-fifths of it—is made up of nitrogen, a colourless, odourless gas, which goes into and comes out of the lungs without any change. For animals the most important gas is oxygen, which is necessary for life and also for burning. Air also contains small traces of carbon dioxide, a gas that is essential for the growth of green plants.

Water vapour—also a gas—is present in the air in varying quantities, depending on local weather conditions. There are also small quantities of other gases in the air. Sometimes air contains odours, and tiny bits of solid materials such as smoke or dust or pollen. Children should be encouraged to think of air as a gas that contains many kinds of materials. They may think of air as a gas, as contrasted with a liquid like water or kerosene, or with a solid such as iron or rock.

Air has weight (although it weighs very little); that is, *air is matter.* Because it has weight, air exerts pressure. Like other gases, air constitutes a fantastically large number of molecules, each in rapid, random motion. Some children may have a slight acquaintance with these terms and concepts. However, it is best not to introduce new words at this stage unless children themselves bring them into the classroom discussion.

**1(b).** AIR CAN BE MADE TO MOVE

Though children everywhere have many experiences which indicate that air is in motion, they are likely to think not of 'air in motion' but of 'blowing with their breath' or of a 'breeze' or 'wind'. Already (see above), however, they have been helped to learn that breath is air. Accordingly, when they 'blow their breath,' they are causing air to move. When they create a breeze with a fan, they are making air to move. Outdoors, there are forces in the atmosphere which make air move and produce breezes, winds or storms. The following activities can help children find the first-hand evidence of the movement of air.

**Investigation**

### Does moving air exert force?

*Materials required*
cycle tyre, tyre pump

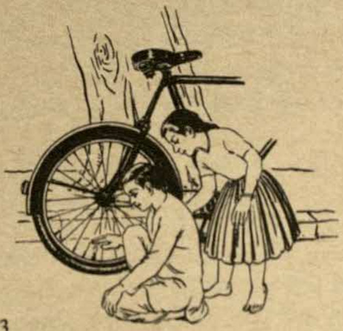


Fig. 2-3
Children can feel that air from a cycle tyre exerts force.

Bring a bicycle into the classroom. Children who have not already had this experience should be asked to hold their hands near the tyre valve as the air is let out, as in Fig. 2-3. Thus they can easily feel the force produced by the air moving out. If a tyre pump is available, it can be used for the same purpose. If a tyre is used, there should be some arrangement for re-inflating it.

**Class Project**

### Let us fly kites

*Materials required*
wood, paper, glue and string to make and fly kite

Help children to make and fly kites. Many children will already have had this experience. Perhaps a kite-flying contest can be arranged. Through the first-hand experience of feeling the tug of the kite string, children can be helped to realize that wind—which is moving air—exerts force on the kite. It is this wind-produced force which prevents the kite from falling.

**Familiar Experience**

### How can moving air be felt?

Have children feel the sensation when the moving air strikes their faces or hands. Usually they feel the coolness of the breeze. They should also be helped to notice the force, usually quite small, produced by the moving air.

*On a larger scale, tell students about the forces produced outdoors by breezes, winds or gales. In extreme cases, the forces produced in severe storms can be unbelievably great.*

*Allow small bits of paper or straw to be moved about by moving air, or by blown breath. Help children describe what they see in terms of the force produced by the moving air.*

### 1(c). AIR OCCUPIES SPACE

The concept that air occupies space is closely related to the understanding that air is *something*. Hence many of the learning activities in that section apply here also. In addition, the following two are particularly useful.

**Investigation**

**Does air occupy space?**

*Materials required*
drinking glass,
cork or chip of wood,
pan or large bowl, water

Invert a drinking glass and lower it over a cork or a similar object floating on the water, as in Fig. 2-4. As the glass is pushed downward, ask children to observe the action of the cork. It goes down with the water surface. Ask children what pushed the water down. It was the air trapped inside the inverted glass. Thus air occupies space; it is a real material which can push down the water. Repeat this investigation using a lamp chimney in place of a drinking glass. Although the air within the chimney still occupies space, it is no longer trapped and so can move out of the top opening of the chimney as it is lowered into the water.

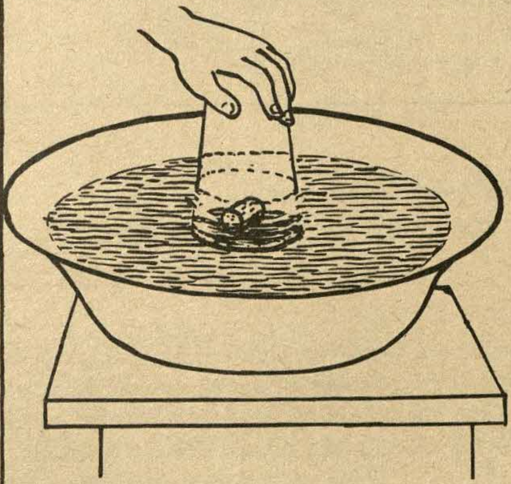


Fig. 2-4
The air inside the tumbler takes up space; it pushes down on the water surface inside the tumbler.

**Investigation**

### How can air be moved from one place to another?

*Materials required*
clear glass jar,
blocks to support jar,
pan or large bowl,
flexible tubing (50 cm),
coloured water

Fill a clear glass jar with coloured water and support it on blocks, as shown in Fig. 2-5. (Do not encourage questions about why water remains in the jar, as it may distract you from the real purpose of the activity). Now blow air into the jar through a flexible tube. Have children note how the water now comes out of the jar. Help them explain this in terms of the fact that the air blown into the jar occupies space, and therefore pushes the water out. If the air is now carefully sucked out of the jar, the water comes back in. This is also an excellent activity to illustrate that air is really something; you can put air into a jar and take it out again.

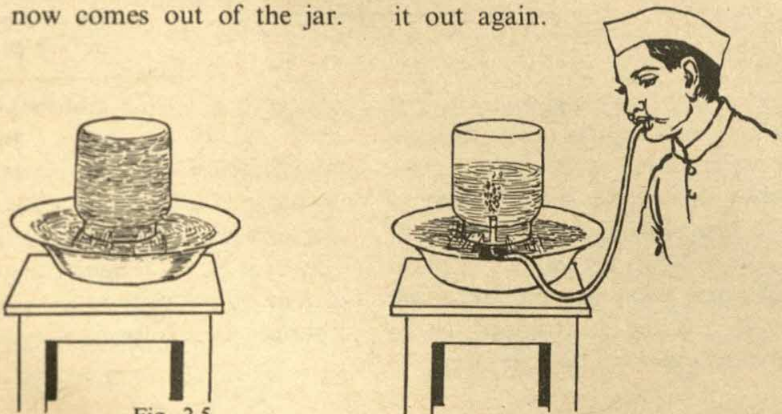


Fig. 2-5
When air is permitted to enter the glass jar, it takes up space; as a result, the water is pushed downward.

*Permit children to inflate balloons, paper sacks or plastic bags. Help them form a generalization that it is air (breath) which inflates these things.*

### 1(d). AIR OFFERS RESISTANCE

Objects moving at slow speed encounter very little resistance from the air. (If they had encountered more, children would be more apt to realize that air is *something)*. While running or riding on bicycles or scooters, however, children have many first-hand experiences of air resistance. In addition, these controlled activities are useful in developing the concept of air resistance. Here are some simple activities that will make children aware of air resistance.

**Investigation**

### How can air resistance be observed?

*Materials required*
rubber balloon,
sheet of thin paper

Ask a child to toss a deflated balloon to a friend a few feet away, as in Fig. 2-6. Repeat this with an inflated balloon. Let the class observe the difference. Help them explain this observation in terms of the different *size* (area) of the two balloons. The same thing can be done with two identical pieces of paper, one tightly wadded and the other loosely wadded.

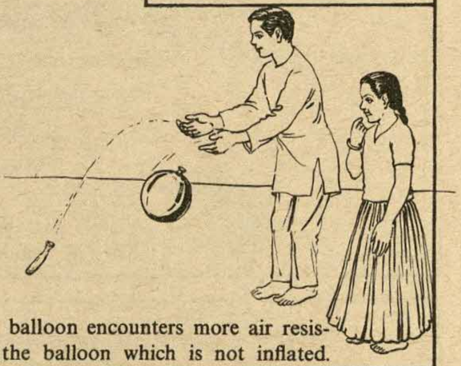


Fig. 2-6
The inflated balloon encounters more air resistance than the balloon which is not inflated.

**Investigation**

### How does air resistance affect speed?

*Materials required*
umbrella

Arrange a foot-race between the two well-matched boys. Let one hold an open umbrella so as to 'catch the air', while the other runs normally, as in Fig. 2-7. Discuss the 'fairness' of the race with the class.

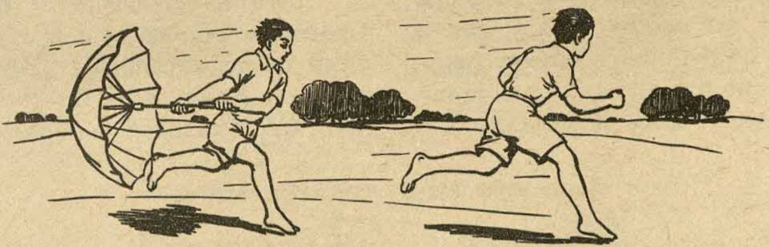


Fig. 2-7
The umbrella's air resistance makes one boy lose the race.

**Investigation**

### How does wind affect the speed of running?

Select two children who can run equally swiftly. Let one run a given distance *with* a brisk wind, while the other runs the same distance *against* the wind, as in Fig. 2-8. Discuss the results with the class; help them understand the difference in terms of air resistance.

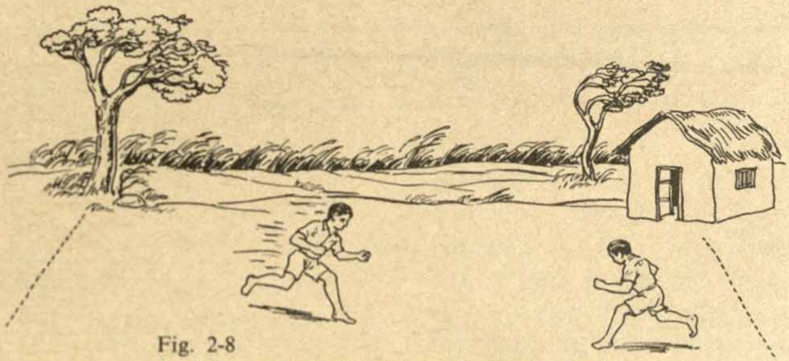


Fig. 2-8
A child running with the wind can run faster than one running against the wind.

*Have a child swing his hand through the air. Let him then repeat with a large, stiff paper in his hand. Ask the class to explain the difference.*

**For Better Understanding**

Objects which move very swiftly through the air are often streamlined to reduce air resistance. Usually this involves a gentle roundness on the leading surface, and a tapered shape on the trailing surface. Aeroplanes and birds provide very good examples. Bullets are rounded in front for this reason, and some are actually slightly tapered at the rear. Sports cars are similarly shaped to reduce air resistance at high speeds. Contrary to popular opinion, however, raindrops are not streamlined. These are nearly spherical. Accordingly, the phrase 'streamlined, teardrop shape' is improper.

### 2. AIR IS NECESSARY FOR MANY THINGS

Young children literally take air for granted. It is around them all the time; most of the changes which air undergoes are invisible. As a result, children are not aware of the essential role that air plays in many daily activities and processes. Of the many ways in which air is necessary, two of the most common and most important are for breathing and for burning. Children are usually conscious of the fact that they inhale and exhale 'breath' or air, but they do not know of the changes involved in the inhaled and exhaled air. In this major concept, beginning can be made to help children realize that air is not only present almost everywhere, but is also highly essential for many purposes.

#### 2(a). AIR IS NECESSARY FOR BREATHING

Adults are fully aware of the role of air (and the oxygen it contains), in support of living animals. But children usually breathe unconsciously. Even when 'out of breath', they are more apt to associate forced breathing with being 'tired' than with a physiological need for oxygen.

Experimentation with animals to show their need for air is to be most strongly discouraged on humanitarian grounds. Within limits, however, children can experiment *with themselves* for the purpose.

**Investigation**

### What does the body need to breathe?

Challenge children to hold their breath for about 30 seconds, as in Fig. 2-9. Then have them note their 'wanting' to breathe deeply. Help them understand that their body needs air. If the body does not get enough air, it causes one to 'want' to breathe. This natural mechanism prevents one from unconsciously continuing a deficient air (oxygen) supply.

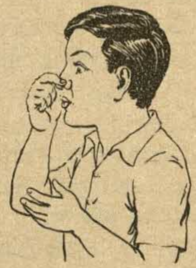


Fig. 2-9
When a child holds his breath for half a minute, he definitely feels the need of air. He *wants* to breathe.

**Investigation**

### How does vigorous exercise affect breathing?

Invite one or more children to undertake a violent exercise, such as running, for a few minutes. Let them and the rest of the class note their breathing rate after this exercise, as in Fig. 2-10. Help the class understand the results in terms as in the previous activity.

Fig. 2-10
After exercise, the boy needs more air; he breathes rapidly and deeply.

*Let a child breathe into and out of a paper bag for a minute. Although he breathes constantly, he soon feels 'out of breath'.*

**For Better Understanding**

Actually, it is the oxygen in air which is necessary for animal life. Many people think that the body extracts *all* the oxygen from the air, but this is not true. Normal inhaled air contains 21 per cent oxygen. Normal exhaled air contains less oxygen; the exact quantity varies with individuals and with the manner of their breathing.

The conscious desire to breathe is not brought about by a deficiency of oxygen but by an excess of carbon dioxide in the lungs. Normal inhaled air contains only a trace (about 0.03 per cent) of carbon dioxide, while normal exhaled air contains *one to two* per cent of that gas. When the air in the lungs contains about two per cent of carbon dioxide, the individual 'wants' to breathe. When it contains as much as four per cent of carbon dioxide, the individual is in genuine distress and discomfort and feels as though he is suffocating—which he is!

When children realize that air is necessary for life, they often wonder how fish breathe. Actually, there is air (more precisely, oxygen) literally *dissolved* in water. Fish 'breathe' by passing large quantities of water over their gills which remove oxygen from water and give off waste carbon dioxide in return.

**2(b).** AIR IS NECESSARY FOR FIRES

From their own experiences and from reading, adults are familiar with the role of air (and the oxygen it contains) in burning. But children often feel that materials burn simply 'because they are hot'. Since children often do not identify air as 'something', they do not associate air with burning.

When fuels burn—fuels such as wood or paper, coal or kerosene—they undergo a chemical combination with the oxygen of the atmosphere. For small children, it is enough to know that a burning fuel combines with or 'uses' a part of the air. Fires cannot exist without air, particularly that essential part of air which the burning fuel requires. Activities below will help make children aware of the dependence of fire on air.

**Investigation**

**What do candles need in order to burn?**

*Materials required*
drinking glass or glass jar,
candle,
matches

Place a drinking glass or a glass jar over a burning candle. Be sure that the edge or lip of the glass container fits fairly tightly the surface of the table on which the burning candle rests. Close observation reveals that the candle flame gradually becomes smaller and smaller as the necessary part of the air is consumed. Finally, the flame dies. Challenge children to observe and explain the results. Help them understand that the flame goes out because it has consumed from the container the entire part of the air which is needed for burning. Repeat this activity with containers of different sizes. The larger the container, the longer the flame lasts. Do not tell this to children, but let them form the generalization on the basis of their own observation. Help them understand why this is true in terms of the flame's need for something in the air. See Fig. 2-11.

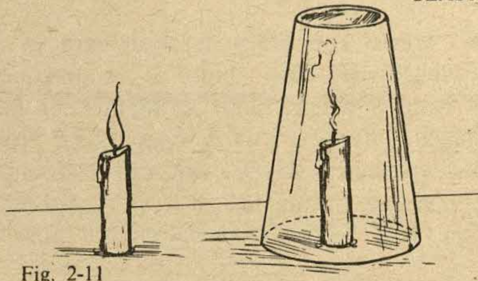


Fig. 2-11
The candle burning in a closed air space soon goes out; it has run out of something in the air—something needed for burning.

*Have children observe the openings on the sides of a 'chula' in their home. These are provided for air to enter. What happens to the fire if they are closed?*

**For Better Understanding**

Adults, of course, realize that flames require only the oxygen from the air. What they often do not realize is that fuels, when they burn, consume much less than the total oxygen content of air. Normal air has about 21 per cent oxygen. Yet a typical candle flame consumes less than half of this! Actually, a candle trapped under a vessel as in the previous activity gets extinguished when the oxygen content drops to about 15 per cent. The exact quantity of oxygen consumed by a flame depends on the nature of the fuel used.

The use of food by plants and animals bears a close and interesting relationship to the burning of fuels. In both plants and animals this food-consuming process is called *respiration*. This is not to be confused with *photosynthesis*, the process by which green plants use raw materials (carbon dioxide and water) and the energy from sunlight to produce food. Also, respiration is more than just inhaling and exhaling. In the process of respiration, food is combined with oxygen *within living cells*. This chemical reaction produces energy which the organisms need to sustain life. Of course, this respiration does not occur nearly so rapidly as the burning of fuels, and children must not be led to believe that there are miniature flames within their living bodies. However, the burning of butter or other fat in a flame is chemically the same general kind of reaction as the combination of fatty foods with oxygen within the body.

Common fuels are not the only things that combine with the oxygen of the air. Many foodstuffs will burn, as every cook knows. This is to be expected, since energy-providing foods are by their nature fuels. Under proper conditions, many metals will also burn. Iron, copper, lead and others will burn if they are hot enough. Finely-powdered iron or even dry steel wool will sparkle when held in a hot flame providing evidence that the metal is burning in the literal sense of the word. The finely meshed wire in a photographic flash bulb is magnesium (a metal), which burns brilliantly in the oxygen with which it is surrounded. Iron also combines slowly with the surrounding oxygen during the process of rusting. Here, too, energy is given off, but not in quantities ordinarily observable. All the above are examples of oxidation. Only when oxidation occurs rapidly enough to provide substantial quantities of heat is it referred to as *burning*, or by its more proper checmical term, *combustion*.

## 3. WATER IS NEEDED FOR LIFE

Children know full well that water is needed for drinking. Some of them are also aware that water is needed to keep clean and cool. However, they usually do not realize the many other ways in which water is needed, directly and indirectly, by human beings, nor do they understand why it is that water is so essential. In this major concept, children can make a start at seeing a great variety of needs for water. At a higher class level, they will be in a position to explore *why* water is so essential.

### 3(a). WATER IS NEEDED FOR LIFE, FOR DRINKING

As in so many cases, children take the drinking of water for granted. They drink water because they are thirsty. They seldom give thought to the fact that water is an absolute necessity of life.

It is not humane to experiment with animals to demonstrate their need for water. However, even young children have had many experiences which point to animals' dependence on water. These can be discussed in the class as below.

**Familiar Experience**

**Do people and animals need water?**

Have children recall their own experiences with the need for water. Have they or their parents taken supplies of water on journeys? Have they had to provide water for livestock or other animals? Have they ever had experiences where they or their animals actually suffered for lack of water? Have they heard of instances when animals died for lack of water?

*Ask each child to count how many times he takes water during one whole day.*

*Keep track of how much water the whole class uses from the water pitcher each day.*

## For Better Understanding

While participating in such discussions, children are often curious about how certain animals get their water. Most animals, including birds, can be observed drinking water. But what about insects? Most insects obtain water entirely through the food they eat. Children can be reminded that much of their own water is also obtained from foods rather than through simple drinking. Another example is the familiar house lizards. They are not seen drinking water; they obtain their needed water from the bodies of insects and other kinds of food which they eat. Camels, of course, need water just as do other animals. However, the physiology of the camel is such that the animal has an uncanny (and extremely complex) ability to store water so that it can survive for several days under waterless conditions.

Water is necessary for animals and plants because the entire internal living processes of the organism are based on water. Food and wastes are dissolved in water; so are oxygen and carbon dioxide (these are also chemically combined with blood). All animal tissues consist largely of water. Most animals, including man, can go without food for many days. Depending on conditions, however, they can survive no more than a few hours—at most a day or so—without water in some form.

### 3(b). WATER IS NEEDED FOR LIFE, FOR WASHING

Some children regard washing simply as a parent-imposed nuisance. Others realize that washing gives comforting relief from heat, perspiration and dust. As a rule, however, they do not realize that washing is essential for cleanliness and health, and in some cases, for sheer survival. In extreme cases, food that is not washed is poisonous. Anyone who keeps his body clean by washing is healthier than he who does not do so. Clean clothes and clean homes make for healtheir living than do dirty ones.

While water is a good enough material for washing, it can often be improved by the addition of other substances. Grit and grime can usually be removed with water and sand or other scouring agent, but some kinds of dirt, particularly oily or greasy dirt, can be removed much more easily if soap is added to the water. This can be made clear with the help of the following activities.

**Investigation**

**How does soap help wash dirt away?**

*Materials required*
grease or oil,
soiled clothing,
soap,
cold water,
hot water

Ask two children to put some greasy material on their hands—a material such as clean lubricating grease, or vegetable oil. Let one try to wash his hands only with water, while the other uses soap as well. Similar experiments can be made with other kinds of dirt using warm water and cold water in turn. Children may be permitted to wash in school those portions of their clothing which are easily soiled by oil and dirt from the body. In particular, collars and cuffs of shirts may be subjected to such experimentation. These investigations easily lead children to the conclusion that clothes are most effectively washed with warm, soapy water.

*Ask children to list the reasons why they wash themselves (to remove dirt, sweat, and dust, to get cool, etc.)*

*Invite children to describe when, how, and how often they wash themselves during a day.*

**For Better Understanding**

Children are usually conscious of visible dirt. What they do not realize is that dirt is usually accompanied by micro-organisms—germs—which can be very harmful to the body. Often, germs are present when visible dirt is entirely or nearly absent. One of the reasons why soap is so effective in washing is that it not only removes visible dirt, but also kills many germs.

**3(c).** WATER IS NEEDED FOR LIFE, FOR COOKING

Some forms of cooking, such as frying, do not depend much on the presence of water. Many methods of cooking food, however, involve water in a very essential way. This is obviously true of such procedures as boiling or steaming or simmering or stewing. In some other forms of cooking, water plays a less obvious but a very important part. For example, meat is roasted partly by being steamed in the vapours of its own juice. Corn pops because the moisture within the kernel changes into steam that expands and bursts the hard outer coating of the seed.

While discussing the role of water in cooking, it is useful to perform some simple cooking procedures in the classroom.

**Investigation**

**Does cooking require water?**

*Materials required*
cooking utensils,
simple food to cook,
source of heat

Carry on such simple cooking processes as boiling of eggs or cooking of potatoes in the classroom. If possible, do this in such quantity that children can at least have a small sample of the product. Point out the role of water in these and other common kinds of cooking.

**Interview**

**How does water help in cooking?**

Invite children to talk to their parents about cooking, or to observe and assist them in simple cooking procedures. Help them observe how large a part water plays in ordinary cooking.

*Help children compare the quantity of cooked food they eat with the quantity of uncooked food.*

*Invite children to sample uncooked pulses or grams or other grains or vegetables which are usually cooked before they are eaten.*

**For Better Understanding**

There are at least three purposes of cooking foods. The first is to make food more easily digestible by human beings, the second is to make it more tasty and the third is to make it hygienic as the temperature at which food is cooked kills nearly all germs and infectious organisms. Water and milk should be boiled before drinking in order that micro-organisms are destroyed. Some meat, such as pork, if not properly cooked, can cause a person an extremely serious disease (trichinosis).

### 3(d). WATER IS NEEDED FOR LIFE, FOR PLANTS

Even small children have had personal experiences of plants' need for water. Particularly in rural communities, they may have participated in supplying water to plants in fields or in gardens. Certainly they have observed their parents or community field workers pumping or hauling water for crops. Perhaps they have heard their elders' concern when water supply seems in danger. It is useful, however, to add first-hand experience to children's background of the role of water in plant life.

**Class Project**

**Do plants need water?**

*Materials required*
indoor plants,
water

Arrange to have plants grown in the classroom. Make the watering of plants a part of the classroom activity. Rotate this responsibility among children in the class, so that they can have first-hand contact with this phase of plant care.

**Investigation**

**Is water needed for plant growth?**

*Materials required*
two identical indoor plants,
water

Conduct an experiment, using two or more identical plants. Provide one plant (or set of plants) with normal water, and keep a record of the watering schedule. Treat the other plant (or set of plants) in precisely the same way, but with no water. It will not be long before a difference is noted as indicated in Fig. 2-12. If the unwatered plant is given normal watering before it is too severely damaged, it may recover.

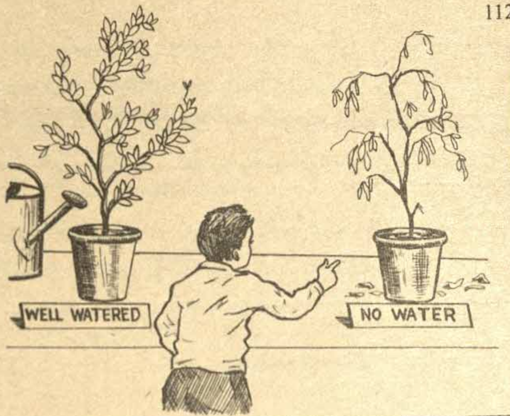


Fig. 2-12
A simple investigation shows that plants with enough water are healthier than those with little or no water.

*Ask children to describe the working of a well near their homes. Compare the different patterns of using the well.*

**3(e).** WATER IS NEEDED FOR LIFE, FOR ANIMALS

The obvious need that animals have for water is for drinking. Hence, the principles and the activities involved in this concept are the same as in 3(a) of this unit. In addition, animals need water for bathing and in some cases for keeping cool.

### For Better Understanding

There are other less obvious needs that animals have for water. The principal one of these involves the concept of the *food chain*. Green plants are able to convert the energy of sunlight directly into food, but animals cannot do this. Hence, animals get their food energy by eating plants or by eating other animals which get food energy indirectly from plants. For example, cereal grains and wild grasses use the energy of sunlight to manufacture food by photosynthesis. Many birds and deer use grain and wild plants for food. Some wild animals such as foxes and leopards eat birds and deer to get food energy. Some larger animals devour foxes and leopards, extending the food chain even farther. When a man eats the meat of ducks or deer, he is participating in the food chain, just as he does when he eats plants of any kind. Insects which usually do not drink, obtain water from foods which they eat. Similarly, the house lizard gets its water from the bodies of insects which it eats.

In addition to the needs that animals have for water as part of the food chain, there are some animals and plants which grow directly in water. A few animals swim in or on water and hence need water for that purpose.

**4.** WEATHER CHANGES FROM TIME TO TIME AND FROM DAY TO DAY

*It may be:*
*a. dry or moist*
*b. hot or cold*
*c. sunny or cloudy*
*d. calm or windy*

These four sub-concepts are all descriptive in nature, and are closely related to each other. Hence they are treated collectively here. The purpose of this section is to help students realize that there are great variations in weather.

Weather changes a great deal, not only from time to time but also from place to place. Even small children are aware of the cycle of seasons. Although their personal memories of seasons other than 'now' may not be vivid, they do at least recall the monsoon rains. They also know that during the dry season, including winter, it usually does not rain. For the most part, school sessions are not held during the monsoon rains.

In our country, however, day-to-day weather changes are often not vividly marked. Teacher-organized activities can help children become aware of these minor but important changes.

**Discussion**

### How many kinds of weather are there?

Fix a period during the day—at the same time each day—for talking about the weather. Invite students to observe and describe the weather in terms of moisture (dry or moist), temperature (hot or cold), condition of sky (sunny or cloudy) and atmospheric movement (calm or windy). Help them develop their powers of observation as well as their vocabulary and their ability to describe what they perceive. Encourage them to contrast a given day's weather with what it was the previous day, or the previous week.

**Class Project**

### How does the weather vary?

*Materials required*
large paper to make 'calendar-chart'

Let a 'weather committee' observe weather. Make a simple record of their observations on a large calendar showing the days of the week and the dates of the month, as in Fig. 2-13. On this calendar, use appropriate symbols or simple sketches to indicate moisture, temperature, condition of sky and atmospheric movement. This can be a project rotated among committees for the entire year, and is also useful for teaching children the use of the calendar and of numbers. The result of this activity will be a permanent record of the local weather, and—much more important—increased perception of the weather and appreciation of its variability.

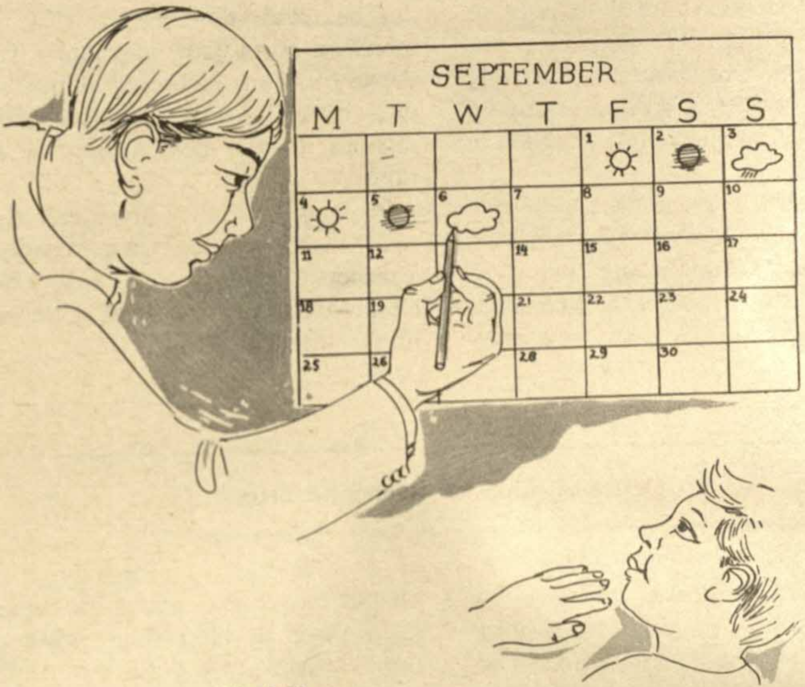


Fig. 2-13
Small children can help make a simple calendar chart of the weather.

*Encourage children to ask their parents about the weather in other parts of India. Perhaps some have been to the places where the weather is distinctly different.*

Weather also exhibits great variations from place to place. Small children who have not travelled much have much difficulty in understanding this concept. Here, too, teacher-organized learning activities can be helpful. Find out if any of the members of the class has lived in other parts of India where the general weather pattern is different. If there is any, ask him to describe the weather of the places he has been to. Perhaps there are adults in the community who can bring to the class their first-hand experiences of other weather patterns.

Prepare a collection of pictures—such as a bulletin board—showing the kinds of weather in other parts of the world. Look for reports in the newspapers or announcements on the radio on weather conditions in different parts of the country. Reports that 'It is raining in Bombay' or 'It is snowing up in the mountains' can help children appreciate variations in weather in different places.

**Scientists at Work**

### What are the sources of scientific knowledge?

We have been learning about air, water and weather. You often learn these things from your parents or from your teacher. Grown-ups seem to know such things already. Where did they learn them from? They learned these from their parents and from their teachers. But way back hundreds or thousands of years ago, where did the knowledge really start? Did it come from scientists? Were there scientists in India or anywhere else in ancient times?

Yes, there were scientists even long, long ago. But they were not scientists in the sense that you think of them now—men and women who spend their entire life learning science, using science and teaching science. Instead, they were ordinary people—parents, farmers and merchants. However, some of them were very careful observers of what went on about them. They were very curious about what they saw. Perhaps they noticed that they were sometimes 'out of breath' and they wondered why. They did simple experiments and made more observations. Although they were common people, they were doing the work of professional scientists.

All the scientific knowledge we have —whether it is simple or complicated— has come from people. You sometimes get this knowledge from adults. When you are older, you will get it from books or newspapers, as other grown-ups do. But somewhere, sometime, every bit of knowledge came from the observation and curiosity of someone.

In your work with air and water and weather you have had a chance to make many observations yourself. You have a first-hand evidence of much of the science you are learning. In this way, you sometimes develop for yourselves knowledge which other people have developed long ago. In this way, you learn important and interesting scientific knowledge. You also learn how scientists find out things. At this class level, you can already behave like a scientist! You can observe, you can be curious about things and you can think! Do you enjoy being a young scientist?

### For Better Understanding

Weather may be thought of as the sum total of all atmospheric conditions. The conditions listed at a, b, c, and d above are most obvious, but there are others as well, such as barometric pressure, relative humidity and amount of rainfall. However, it is not the purpose of this section to give children an analytical understanding of the causes and prediction of weather, but to enable them to recognize its principal characteristics and to appreciate its variety.

The terms 'weather' and 'climate' are often confused. Although related, their meanings are not the same. 'Weather' is the sum total of all atmospheric conditions at a given time and place. 'Climate' describes the general weather conditions over a period of several weeks or more. For example, on a given day the *weather* may be rainy in Ajmer, although the *climate* there is dry. Or, on a certain weekend the weather may be very warm and humid at a hill-station, although the *climate* there is generally cool and refreshing.

Even so, children are bound to ask about the causes of the different weather conditions. Partial answers such as 'clounds are made up of tiny droplets of water (they are *not* water vapours)', or 'rain comes from moisture which has evaporated into the air' may be given. Actually, the causes of weather are extremely complicated, and professional meteorologists devote their entire career to understand some of them. Fundamentally, weather is energy that comes from the sun. Therefore, it can be said that the sun-and-earth system is a giant thermal engine, one result of which is the constantly changing patterns of weather.

# UNIT 2

# AIR, WATER AND WEATHER

## CLASS II

### Overview

Man is completely dependent on air and water. In particular, air is needed, among other things, for man's breathing and for the burning of fires. Water is used not only for drinking and for bathing, but also for growing plants. It is also needed for animals and for many other purposes. Man's relationship with weather is not limited to personal comfort or discomfort; man is also affected by weather in terms of his agriculture, his travel, and his sources of water. It is natural, therefore, that man studies these aspect of science, so that he can understand them more and use and control them better.

At class I level, children have learned that air is something, that it is found nearly everywhere, and that it has many uses. They have also learned some of the uses of water, and that there is a great variety of weather conditions. At class II level, they begin to learn something of the concepts of air—its water vapour and its dust and dirt and their effects on man's living. They learn that air in motion is wind—one aspect of weather They also learn about some common sources of water, and about the impurities which water may contain. Finally, they begin to learn about the water cycle, evaporation and rain. They also begin to see some of the important interrelationships among air, water and weather.

Children in class II should not be burdened with too much specific factual information in this area. Instead, teachers should emphasize the broad general concepts involved in these matters. They should point out the various uses of air, water and weather and the pleasures they provide for man.

### 1. AIR CONTAINS WATER VAPOUR

In the order of their abundance, the gases in normal dry atmosphere include approximately 78 per cent nitrogen, 21 per cent oxygen and 1 per cent argon. Other gases, including carbon dioxide, are present in small traces. Besides these, water vapour is present in varying amounts. This section is concerned with helping children acquire simple concepts related to water vapour in the air.

**1(a).** WET CLOTHES DRY BY EVAPORATION

One of the earliest contacts which small children have with evaporation is through the process of drying clothes. They have seen their parents or others drying clothes by spreading them out. Some children might even have helped in this work. Almost every child has had the experience of spilling water on his or her clothes and then having the clothes dried up while still on the body. Additional classroom learning activities may or may not be necessary

**Investigation**

**How does water evaporate from clothes?**

*Materials required*
wet cloth

Wet some cloth and spread it out to dry. Have children feel it from time to time while it is drying. Help them realize that when clothes dry, the water which has made them wet, evaporates into the air. This is not a sudden change, but a *gradual process*

**Investigation**

**Can we see water evaporate?**

*Materials required*
chalk board,
wet cloth

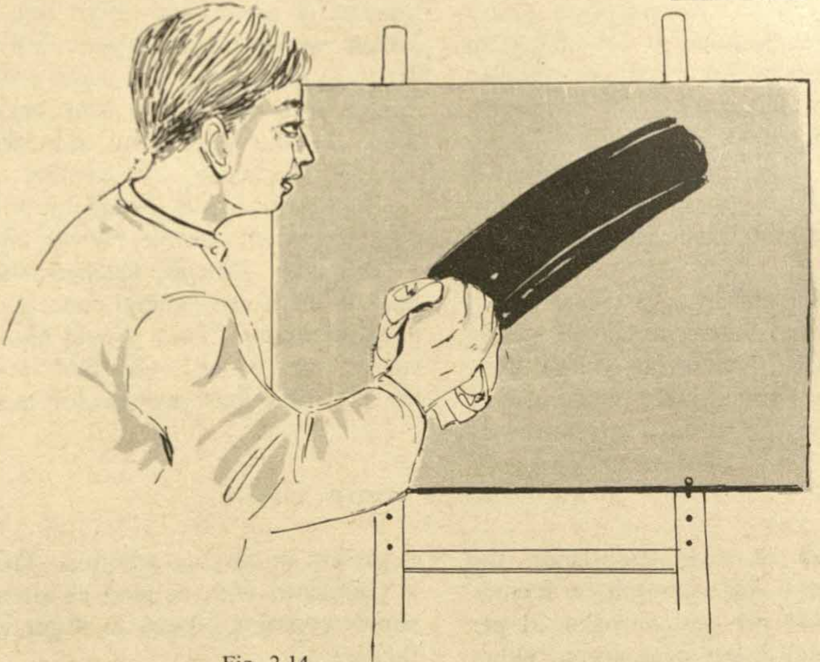


Fig. 2-14
Dampness on a blackboard quickly evaporates and becomes invisible.

Use a damp cloth to spread a thin film of moisture on the chalk board. Usually this will dry *while the children watch it,* as suggested in Fig. 2-14. Help them to speculate on what happens to the water while it evaporates, and to accept the idea that it doesn't simply 'cease to exist', but rather, becomes an invisible part of the air.

*Point out that perspiration from the skin dries in a breeze, that is, the water in the perspiration evaporates.*

*On a warm day invite a boy to wet his shirt, and to wear it. Note how long it takes for the shirt to dry.*

Children sometimes have the idea that wet clothes dry simply because they are warm. Here is an activity which will help them understand the situation properly.

**Investigation**

## Can warmth alone dry clothes?

*Materials required*
two pieces of damp cloth,
plastic bag

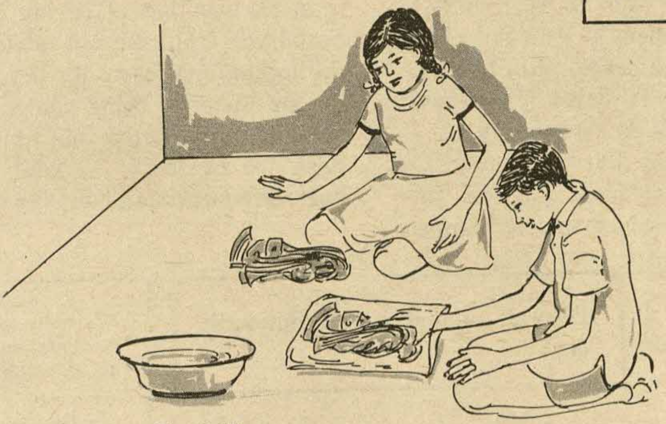


Fig. 2-15
Both cloths are equally warm; but warmth alone does not dry out the cloth inside the plastic bag.

Wet two identical pieces of cloth and wring them out. Place one in a plastic bag as in Fig. 2-15, but not the other. Place both samples where they will get warm. Invite children to predict the results. Later they can see to what extent their predictions were correct. Let them feel the two samples from time to time to see if they are warm. Help them understand that the cloth in the plastic bag failed to dry because the water could not get into the air. That is, the water could not evaporate, even though it was warm.

*Demonstrate that wet clothes can dry even on a cool day, provided the air is not too humid.*

### For Better Understanding

Actually, evaporation is the process of water (or other material) changing from the liquid state to the gaseous state. When this change occurs *throughout* the liquid—and not only on the surface—the process is called *boiling*. The energy for this change comes from the heat which makes the water boil. The change also occurs at lower temperatures, but only *at the surface* of the water. Regardless of the temperature at which water evaporates, the process requires energy. In all common cases, this energy comes from heat. Hence evaporating water extracts heat from its surroundings, and therefore cools them. It is for this reason that while clothes are drying, they feel cool. Similarly, one's body is cooled by the evaporation of perspiration on a warm day.

From this, it is seen that evaporation is a dynamic, energy-consuming physical process, not something which merely 'happens by itself. Also, that the rate of evaporation is increased if the water is warmed (i.e. supplied with heat energy).

The circulation of air—as in a breeze—encourages evaporation by removing air which is already more or less 'full' of water vapour. Thus, when a sari is held up in the breeze, it dries rapidly because relatively dry air is constantly supplied, while the air into which water has already evaporated is removed.

**1(b).** WHITEWASH DRIES BY EVAPORATION

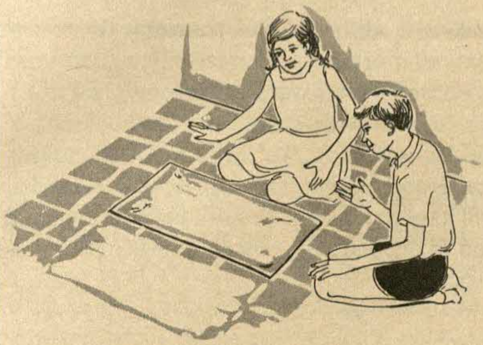
Physically, the process of drying whitewash is much like that of drying clothes; water evaporates from the wet mixture applied to the surface and leaves the dry, white residue on the material being coated. Here again, children often assume that whitewash simply dries 'all by itself.' Suitable activities can help them understand this situation.

**Investigation**

**Does air circulation help whitewash dry?**

*Materials required*
powdered lime, water, brush or cloth (to apply whitewash), sample surface to be whitewashed, box or sheet of plastic

Whitewash two identical samples of surface. Let one of these dry normally, while the other is protected by a wood or paper box, or covered with a plastic sheet as in Fig. 2-16. Invite children to notice the difference in drying time and help them understand why the protected one dries more slowly. Help them understand this difference in terms of the dynamic process of eva-



poration. The same investigation can be conducted by drying one sample in warm sunshine and another in shade.

Fig. 2-16
Whitewash dries faster when the air circulates around it.

**Class Project**

## How do we use whitewash?

*Materials required*
powdered lime,
water,
brush or cloth (to apply whitewash)

Arrange a class project wherein students help prepare whitewash and apply it. Call their attention to the fact that water is added to the powdered lime to prepare the mixture. Help them understand that when the applied whitewash dries, the water leaves (evaporates from) the wet mixture. This activity may be combined with that of improving the appearance of some part of the schoolroom or outside property.

*Let a whitewashed surface dry under conditions when water is occasionally added. This counteracts the process of evaporation and slows down the drying of the whitewash.*

### For Better Understanding

Actually, the drying process of whitewash is a bit more complicated than described here. Any careful observer knows that the powder from which whitewash is made (quick-lime or unslaked lime) is loose and light and does not stick well to a surface. When water is added, the mixture gets hot and sometimes gives out bubbles (bubbles of steam from the heat). The result is a thin paste of slaked lime and water. When this is applied to a surface, it sticks amazingly well. There has been some chemical change in the whitewash powder since it started out as unslaked lime. But once the mixture is prepared, 'drying' is largely a matter of evaporation of the water. Sometimes other glue-like materials are added to whitewash. In such cases, paint does not *dry* on account of evaporation. Rather, there is a chemical reaction between the liquid part of the paint and the atmosphere. The resulting compound is 'dried paint'. It would be more clear if this were called 'hardened paint'.

**1(c).** WHEN WATER EVAPORATES, IT GOES INTO THE AIR

Water vapour is invisible. This, of course, makes it difficult for students to realize that evaporation is more than the mere *disappearance* of water, that the water which has evaporated exists in vapour form in the atmosphere. To help students understand and accept this concept, the teacher will have to use considerable indirect evidence and to depend on children's ability to reason logically.

**Discussion**

**Does air circulation help evaporation?**

Ask children to consider carefully the results of the two samples of water, one freely exposed to the air and the other loosely covered with paper or something similar. [See activity with sub-concept 1(a) ]. Ask them to reason why the covered water evaporates more slowly. Help them realize that the enclosed air space becomes 'full' of water vapour (saturated) and cannot hold any more. If students accept this explanation, it will improve their understanding of the concept that water goes into the air on evaporation.

**Familiar Experience**

**Do clothes dry slowly in damp weather?**

Ask children to recall problems of drying clothes during the rainy season. Help them realize that during this time much water has already evaporated into the air, hence the air is now relatively 'full' of water vapour. It is for this reason that the drying of clothes (evaporation of water from the clothes) is a slow and difficult process.

**Familiar Experience**

**How does water vapour condense out of the air?**

Ask children to recall instances when water vapour from the air condenses on cool surfaces (e.g. formation of dew, collection of moisture on the outside of a glass of iced water). Or permit a child to breathe gently on a cool, shiny surface. [See also activity under sub-concept 1(d)]. Help children realize that this liquid water has come from the water vapour in the air. This reasoning will help them understand that water goes into the air on evaporation.

*Let a small amount of petrol or alcohol evaporate. Have the children notice the odour as the liquid evaporates. Help them realize that if water had an odour, they could smell that too.*

**For Better Understanding**

It is important for the teacher to realize that water in the liquid form remains essentially unchanged when it goes into the vapour or gaseous form. The only difference is that in the vapour form, the molecules of water are widely separated, while in the liquid form, the molecules are essentially touching each other. But the individual molecule (of $H_2O$) is the same whether it is a part of liquid water or water vapour (or, for that matter, part of solid water—ice).

**1(d).** WATER VAPOUR CONDENSES ON COOL SURFACES

Virtually, all children have noticed that the outside of a glass of very cold water becomes moist. Sometimes they say the 'glass sweats' or the 'water oozes out'. While adults realize that this is liquid water condensed from the water vapour in the surrounding air, children often think that this is water which has 'leaked through' the sides of the glass. While it is easy to demonstrate this phenomenon of condensation on cool surfaces, it is more difficult to convince students of its exact cause. Activities such as these will help.

**Investigation**

**Where does water on cool surfaces come from?**

*Materials required*
cold coloured water,
glass jar or tumbler,
sugar or salt

Put cold coloured water (coloured with ink or with tea or food colouring, for example) into a clean glass and invite students to predict the result. Most of them will predict that water will appear on the outside of the glass. Some will predict that the moisture on the outside will also be coloured. When the results are observed and the moisture is found to be colourless water, help children see that this indicates the liquid did *not* come through the glass. The water must have come from the air. This may be modified by using sweetened or salted water or other flavoured beverage and inviting an observer to taste the material on the outside of the glass.

**Investigation**

**Does water on a moist tumbler come from inside?**

*Materials required*
cold water,
glass jar or tumbler,
dry towel or cloth

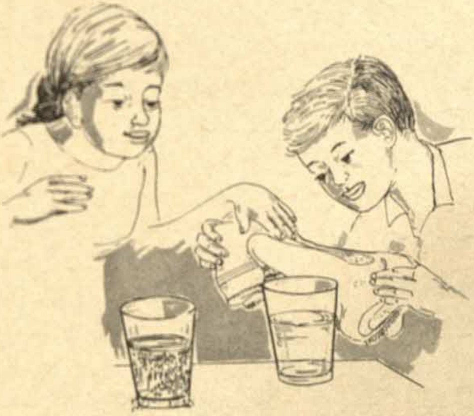


Fig. 2-17
This investigation indicates that the water which appears on the outside of a cold glass does not come through the glass from inside; if it did, *both* tumblers would be moist on the outside.

Put cold water into a clean glass. Before condensation occurs, wrap the glass in a layer or two of a clean dry towelling as in Fig. 2-17. Ask children to predict the result. If water comes through the glass, the cloth will become moist quickly. Actually, however, the cloth remains almost completely dry. Why? Help children realize that this is because very little water-vapour-laden air can come in contact with the cold glass surface when it is protected with a covering of cloth.

*Breathe on a cool surface and observe the moisture which condenses there.*

### 1(e). THE AMOUNT OF WATER VAPOUR VARIES IN DIFFERENT SEASONS

During winter air has relatively little water vapour in it. As a result, evaporation takes place quite quickly However, immediately before and during the rainy season, the atmosphere is apt to have much water vapour in it; so evaporation takes place much more slowly. The difference in the rate of evaporation is primarily due to differences in the moisture content of the air (its humidity).

However, children are much more apt to notice the difference in *temperature* between seasons than the difference in *humidity*. From one season to another is too long a time-span for effective experimentation for young children. Even so, the teacher can call on students' memory of common experiences and help children realize that these are primarily related to relative humidity—the abundance of water vapour in the air.

**Familiar Experience**

**Do clothes usually dry better in winter?**

Ask children to recall how well or how poorly clothes dry during winter and the rainy season. Similarly, they can recall their personal feelings of comfort during the two seasons. A casual discussion will bring out the fact that clothes—and people—keep drier during the winter. But children already know that evaporation takes place better when it is warm than when it is cool. This will suggest that clothes and people dry more readily during the summer. Help children realize that poor evaporation from clothes or from people during the rainy season is due to the fact that the air is already nearly 'full' of water vapour (nearly saturated), so that more water cannot easily evaporate.

*Point out that sticky, sultry days seldom occur except near the monsoon season. When there is little water to evaporate into the air, the air becomes quite dry.*

**For Better Understanding**

Weather scientists discuss the amount of water vapour in air in terms of relative humidity. Relative humidity is defined as the quantity of water in a sample of air divided by the quantity of water that sample *could* hold under existing conditions of temperature and pressure. During the winter monsoon, relative humidity may be 25 per cent or sometimes lower, particularly in very arid regions. But just before and during the rainy season, relative humidity may be 90 per cent or more. It is during this period that clothes dry very slowly. Again, it is during this period that people perspire most because it is hot. The perspiration evaporates very slowly because the relative humidity is high.

### 2. AIR CONTAINS DUST AND SMOKE

Although most of the atmosphere is made up of gases, there is also some liquid and some solid matter suspended in air. The liquid particles are tiny droplets of water which make up clouds and fog. Solid particles may be smoke and dust or pollen. In the higher atmosphere there are snow or ice particles in certain clouds. For the most part these particles are so tiny that their extremely light weight does not make them fall; instead they are constantly tossed about by movements of the atmosphere.

#### 2(a). THERE ARE DUST PARTICLES IN AIR

Children have often seen dust in air, and even more often they have seen smoke. When the visibility is poor, it is often because of dust or smoke particles in the air. However, children seldom have a chance to observe individual dust particles. Here is a way they can have this delightful experience.

**Investigation**

**How can dust particles be seen in the air?**

*Materials required*
source of bright light,
dusty cloth

Arrange a bright light—as from a torch—to illuminate a sample of air as in Fig. 2-18. If the air is unusually clean, some dust may be introduced into it from a dust-cloth. If one looks at this illuminated sample of dusty air against a dark background, individual dust particles can be observed. If conditions permit, the same observation can be made of a sample of air illuminated by the sunlight. Children never seem tired of observing the endless movements of dust particles under these conditions.

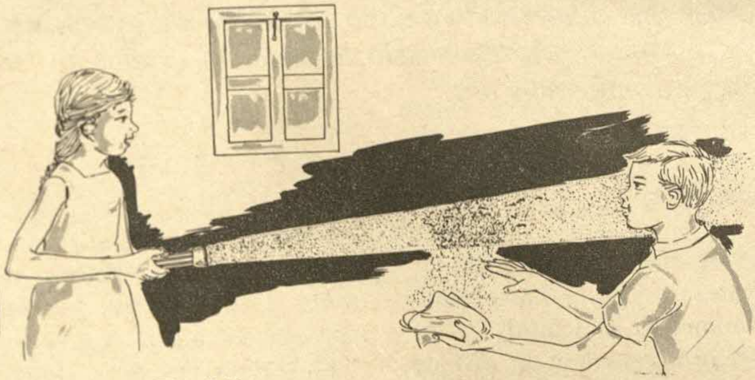


Fig. 2-18
It is easy and interesting to examine dust particles in the air.

*Examine a layer of dust with a magnifying glass.*

*Point out the air condition in a smoky kitchen, or just after the dust has been swept from the floor. The condition may be so bad as to be almost unbearable.*

### For Better Understanding

When making such observations of dust particles, children often ask what makes the dust particles keep moving, and why they do not fall. The particles are kept in motion by the continuous movement of the air. When we say the air is 'still', it is only 'relatively still'. Even under ideal conditions, there are always movements in the atmosphere. These keep the particles moving. In a container of air which is protected from atmospheric movements, one might expect the dust or smoke particles eventually to become motionless. In fact, if such a sample of 'motionless air' is observed through a suitable microscope, particles are seen to be in constant, random movement, due to their being bombarded by the much smaller and invisible molecules of the air. At ordinary temperatures the molecules themselves are in violent, random, vibratory motion.

### 2(b). SMOKE RISES FROM FIRES INTO THE AIR

Children often see smoke rising from fires—fires in chimneys or elsewhere Sometimes they take this for granted, unconsciously assuming, as did the ancients, that 'it is the nature of smoke to rise ' Sometimes children say that smoke rises because it is 'light'. Actually, smoke consists of solid particles of matter, and these are far heavier than a tiny sample of air of the same volume as of a given smoke particle. Rather, smoke from fires rises because it is a part of heated air which weighs less per unit volume—smoke included—than the surrounding unheated air.

Well-selected activities can help children understand that it is the warm air—not just the smoke particles which it contains—which rises because it is light.

**Investigation**

**Does warm air rise?**

*Materials required*
paper pinwheel,
candle or lamp,
match box

Make a small paper pinwheel and pivot it on a pin stuck into a piece of wood as in Fig 2-19 Hold this above a candle flame or a kerosene lantern or even an electric hot plate or an electric lamp Help children conclude that the warm air is rising even though there may be no visible smoke in it

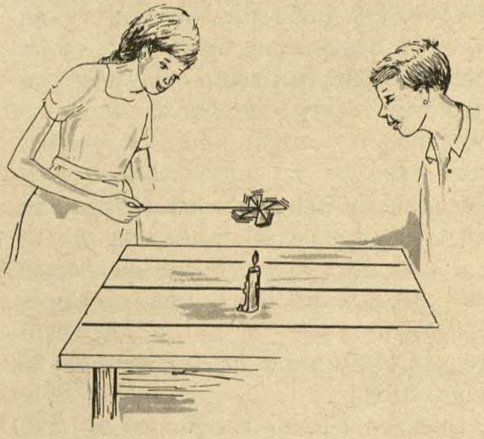


Fig. 2-19
Children can observe that warm air above a flame rises.

**Investigation**

**How does heat cause convection current in air?**

*Materials required*
cardboard box,
clear plastic,
lamp chimney,
candle, match box,
source of smoke

Prepare a convection box as in Fig 2-20 When the air above the candle is heated, it rises, regardless of whether or not the smoke of the candle is visible Incense or damp rope smouldering at the right shows that air moves towards the candle flame, is heated and then rise. Challenge children to reason why the air (and smoke) moves towards the candle flame *before* it is heated.

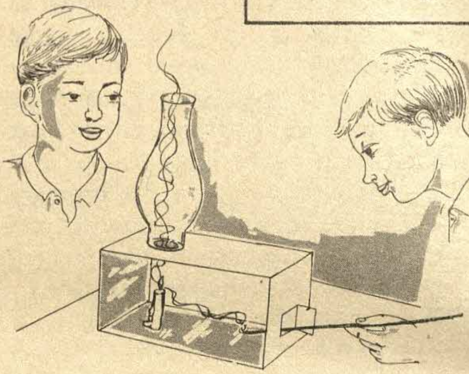


Fig. 2-20
A convection box can help children learn much about air circulation.

*Observe smoke rising from incense, candles, lamps and village fires.*

**For Better Understanding**

A convection box as described above can be used to demonstrate many kinds of air movements. The horizontal movement of air from the right to the left in the sketch corresponds to certain kinds of breezes. In this case the air moves because it is pushed from the right to the left. Air pressure on the right is 'normal', while that on the left is less than normal since air heated by the candle flame moves upward. For a similar reason there is also a downward movement of air in the tube on the right of the convection box.

**2(c).** DUST AND SMOKE MAKE AIR IMPURE

No air is completely free from dust and smoke. There is no detectable harm in breathing 'normally clean air'. In many situations, breathing of smoky or dusty air for a short period is unavoidable. The nasal passages are equipped with tiny hairs and with a moist surface which greatly check the dust getting into the lungs. However, prolonged breathing of very dirty air should be avoided. There is an overwhelming evidence that smoking, particularly cigarette, is harmful to the lungs.

In this sub-concept it is impractical to carry on actual experimentation to detect the effects of harmful quantities of dust and smoke. It is interesting, however, to have students observe how much dust and smoke there is even in comparatively clean air.

**Investigation**

**Is there any dust in clean air?**

*Materials required*
pan of water

Keep a pan of clean water in the classroom for a few days. A layer of visible dust will settle on the surface. Point out that this is the dust which has come from 'normally clean air'.

**Familiar Experience**

**Does all air contain dust?**

Ask children to recall times when they were dusting polished surfaces in school or at home. Remind them of the surprising amount of dust that settles on these surfaces in a few hours, even from 'normally clean air'.

**Familiar Experience**

**Where does dust gather?**

Help children recall their observations of the large quantity of dust which accumulates around electric fans and in corners of rooms and window sills. Help them understand that this is the dust taken from large quantities of 'normally clean air'.

*Call children's attention to how frequently sellers in the bazars have to dust their merchandise.*

### 3. FRESH AIR IS NEEDED FOR HEALTH

The concept of 'fresh air' is often misunderstood. Typically, the term is used to describe air which has a clean and pleasant odour, or no odour at all. The term is also used for air which is refreshingly cool and has reasonably high relative humidity. That is to say, 'fresh air' is a term used to describe air which is pleasant and invigorating. In the sense used in these pages, however, 'fresh air' has a different meaning. The details and the significance of this meaning are brought out in the sub-concepts and related comments below.

#### 3(a). EXHALED BREATH CONTAINS IMPURITIES

Air which is breathed out brings with it moisture and to some extent unpleasant odour as well. While these changes in the air breathed out may be undesirable, they do not make it *unclean*. The impurities which concern us here are those concerned with germs or micro-organisms. Practical experimentation with small children is difficult in this case. However, it will be possible to recall their own experiences relating to this sub-concept.

**Familiar Experience**

**Does air usually contain germs?**

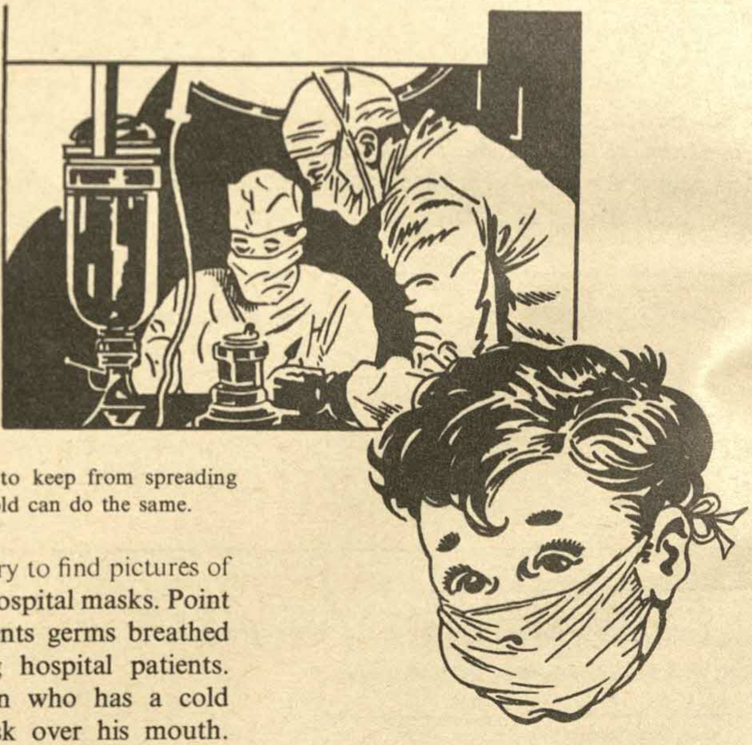


Fig. 2-21
Surgeons wear masks to keep from spreading germs; a boy with a cold can do the same.

Ask children to try to find pictures of surgeons wearing hospital masks. Point out that this prevents germs breathed out from affecting hospital patients. Similarly, a person who has a cold often wears a mask over his mouth. See Fig. 2-21.

*Remind children of health rules which caution a person, particularly if he is sick, not to breathe on others.*

*Remind children that colds, tuberculosis, and other diseases can be caught by breathing air which contains germs.*

### 3(b). WHEN THINGS BURN IMPURITIES GO INTO THE AIR

When an ordinary fuel burns, the only gases which go into the air are carbon dioxide and water vapour. These are invisible. However, most fuels are not pure and usually produce a considerable quantity of smoke.

**Investigation** | **Do all flames produce smoke?**

*Materials required*
candle or lamp,
match box,
shiny glass or metal

Use a candle flame or a kerosene lamp to produce smoke on a piece of glass or shiny metal. There is more smoke when the wick is long.

*Remind children of the smoke produced by lamp flames and kitchen fires.*

**For Better Understanding**

It is extremely uncommon for an ordinary fire to produce so much carbon dioxide or to consume so much oxygen from the air that it constitutes a hazard. Some kinds of fire, however, do produce certain harmful by-products. Usually they also produce choking fumes, so that one is aware of the fact that the air is unclean. This is when smoke is very heavy or when sulphur or rubber is burning. Under certain conditions fire produces the poisonous gas carbon monoxide. This is usually produced under conditions where flames burn with an insufficient supply of oxygen. Coal fire in closed rooms may produce carbon monoxide in this way.

### 3(c). DOORS AND WINDOWS PROVIDE FRESH AIR

Most children realize that doors are provided so that people and animals can go through them and that windows let the light in. Sometimes children do not realize that doors and windows also permit passage of fresh air. The following discussion may help them towards better comprehension of this sub-concept.

**Discussion** | **What is the use of doors and windows?**

On an appropriate day when the air in the schoolroom is a little stuffy, invite children to suggest what they might do about it. They will suggest that doors or windows be opened. Let them realize that by doing this, they are not only permitting fresh air to come in from outside but are also permitting the stale air from inside the room to be driven out.

*Ask children why they often sleep out-of-doors when it is very warm. (They do this because of insufficient ventilation in their homes—there are other reasons also). See also activities under Unit 6, Housing and Clothing.*

### 3(d). PEOPLE GO OUT-OF-DOORS TO GET MORE FRESH AIR

Children often think that they like to play out-of-doors because there is more space, or simply because the games they wish to play cannot be played indoors. They often fail to realize that the fresh air out-of-doors makes their play more enjoyable. Teachers can help students realize this through such discussion and activities as below.

**Discussion**

**Why do most children like to be out-of-doors ?**

On appropriate day when there is a games period within the school day, ask children whether they would prefer to play indoors or out. Unless the weather is bad, they will naturally prefer to play out-of-doors. Help them analyze why this is so. Some will say that there is more space and perhaps to some there is more fun outdoors. Through this discussion try to help children realize that other things being equal, the comparative freshness of the outdoor air is a distinctive factor in their preference for playing outside.

*Ask children where (indoors or outdoors) and why they feel most vigorous, and most wide-awake.*

### 4. WIND IS AIR IN MOTION

Air—the atmosphere—would be much less interesting, much less important, and much less useful if it were always motionless. Actually, the out-of-doors air is almost always in motion, sometimes violently. Sometimes these motions are upwards or downwards, and people often do not notice them. But when the outdoor air moves horizontally, it is called a wind. It can be a weak wind called a breeze or a very strong one, such as a gale.

## 4(a). WIND HAS DIRECTION

Small children often think that wind is something distinctly different from 'air'. They fail to see that wind is simply air in motion. Simple experience can provide children with the evidence they need to understand this important relationship.

**Investigation**

**What is wind?**

On a day when there is a gentle breeze outside, ask children to observe it carefully. Encourage them to compare the condition in an open area, where the breeze can be felt, to that in an area protected by walls. Help them realize that the only difference in these two situations is that in the former the air is moving, while in the latter it is not.

**Investigation**

**How can children produce artificial wind?**

*Materials required*
stiff paper or
electric fan

Consider with children the possibility of an 'indoor wind'. It can be produced by a sheet of stiff paper used as a fan as in Fig. 2-22 or even by blown breath. Help children discover the evidence that the wind is blowing as 'it makes dust and small bits of paper move, or 'it cools the skin if the hand is moist'. Inside the classroom, use this evidence (or lack of it) to indicate that there is no wind. Now produce an 'artificial wind' and help students observe the evidence for the wind. Help students realize that the wind can be produced simply by moving the air, regardless of whether the moving force is natural or an artificial one.

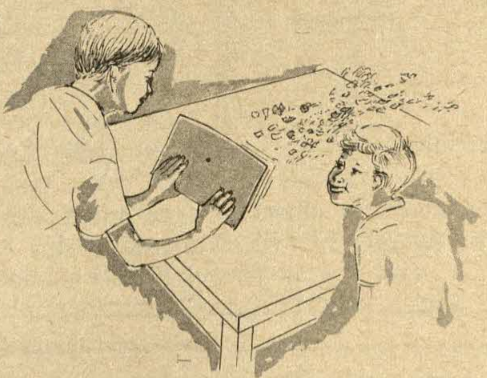


Fig. 2-22
When air is made to move, an artificial wind is produced.

*Challenge children to identify the wind direction with their eyes closed.*

Once children realize that the wind is air in motion, they are ready to consider the direction of the wind. People identify winds by the direction *from which they come*. A man from France is called a Frenchman, and a woman from Japan is referred to as a Japanese. So a wind from the south is called a south wind. Appropriate activities can help children become conscious of the direction from which winds come.

**Class Project**

### Can we make a wind-vane?

*Materials required*
wood,
sharpened nail,
simple hand tools

Challenge children to identify the direction of winds They should be named by the direction *from which* they come, such as a north wind, or a southeast wind This can be done by observing the direction *from which* dust, papers, and smoke are moved by the wind It is also possible to make a simple wind-direction indicator from the readily available materials as suggested in Fig 2-23.

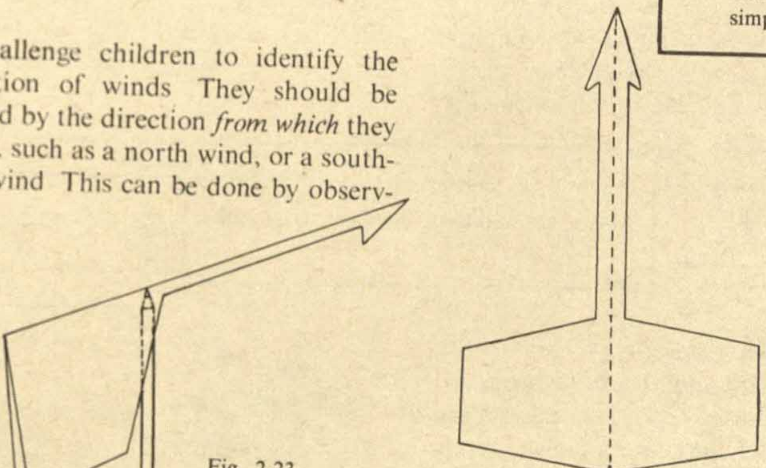


Fig. 2-23
A workable wind-vane can be made from paper or wood.

**Class Project**

### Let us keep a record of the wind direction

*Materials required*
chart for keeping records

Encourage the class—or a special committee of the class—to observe and record the direction from which the wind comes in the morning, at midday, and in the afternoon for a period of several weeks. Fig. 2-24 suggests how this might be done. This will help them become aware of the wind direction. It will also provide valuable experience in collecting first-hand evidence about the day-to-day variety in the wind conditions. The teacher must bear the main burden of keeping the records.

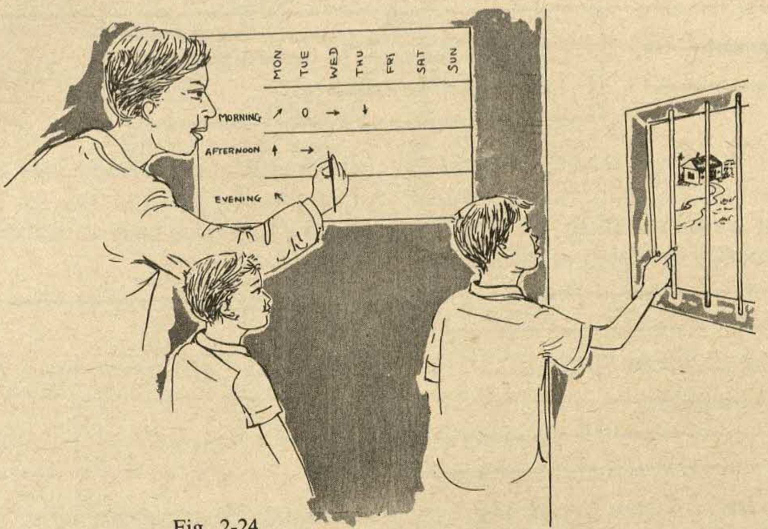


Fig. 2-24
Children can help maintain a record of the direction of the wind.

*Challenge children to tell the direction of the most common wind from the ways in which trees and bushes grow.*

**4(b).** WIND HAS SPEED

Like anything else which moves, moving air (wind) has speed. This is commonly expressed in terms of miles or kilometres per hour. The easiest way to estimte the wind speed is to observe the speed of dust or smoke as it is moved by the wind. Children can be involved in such activities in this way.

**Investigation**

**How can the wind speed be estimated?**

Challenge children to estimate the speed of the wind by observing the speed of dust or smoke in the air. In so doing, have them recall that even the swiftest runner among small children can seldom exceed a speed of perhaps 10-12 kilometres per hour. If the wind is moving more swiftly, children may have to estimate its speed with the help of an older child who can run faster, or a child riding a bicycle. Children can also get some idea of the wind velocity from the pressure it produces on their bodies but this provides only a very rough measure.

**Investigation**

**How can the speed of winds high in the atmosphere be estimated?**

On a day when there are scattered clouds, observe carefully the movement of their shadows along the ground. By estimating the speed of the shadow, children can get a good idea of how fast the clouds—and the air around them—is moving high up in the atmosphere.

*Ask children to describe the results of the strongest wind they can remember.*

*Invite children to ask their parents about the strongest wind they can remember, and report the accounts to the rest of the class.*

### 4(c). WIND CAN EXERT FORCE

The fact that the wind exerts force on things is obvious to an adult. He has his personal experience and his observation of things being pushed around by the wind. However, this is not so evident to children, who have little, if any, concept about force. Indeed, this sub-concept constitutes one of children's early contacts with the concept of force. A simple idea of force is in terms of 'push' or 'pull'. This way of describing force is incomplete but adequate at this class level. Pushes and pulls are common experiences of children. Of course, the wind does not pull on things, but it very often exerts force in the form of a push. It is this push which makes smoke and dust and papers move in the wind, and which makes trees rustle, or even uproots them. It is this force which keeps children's kites up in the air, and which moves sailboats across the water The task of the teacher here is to introduce the concept and the term 'force' into children's thinking as they relate the wind to the movement which it causes. Discussion based on everyday observations and simple experience can help.

**Investigation**

**Can children feel the force of the wind?**

*Materials required*
jackets for some children

On a day when the wind is very strong, arrange for children to stand in the wind with their jackets outspread or with holding large sheets of cardboard in their hands as in Fig 2-25 Under these conditions they can feel the force of the wind on their own bodies.

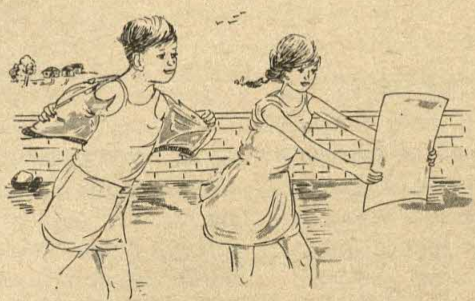


Fig. 2-25
It is easy to feel the force of the wind.

**Discussion**

**How can we tell if the wind is blowing?**

Challenge children to tell, simply by looking through a window, whether or not the wind is blowing outside. Help them realize that their evidence is in term of things which move—trees, dust, smoke, clouds, and clothes hanging out to dry. See Fig. 2-26. Help them understand the cause of this movement in terms of the force exerted by the wind.

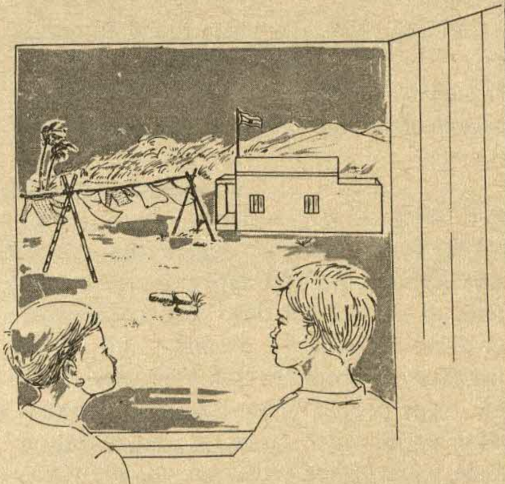


Fig. 2-26
There are many kinds of clues to tell that the wind exerts force.

*Get pictures of sailboats to illustrate the usefulness of the wind's force.*

*Show pictures of a windmill to indicate how the force of the wind can be used to do useful work.*

### For Better Understanding

The wind—moving air—cannot be seen; nevertheless, it is a real substance. It is made up of molecules. These molecules normally exert the force commonly spoken of in terms of air pressure. But when the wind is moving, the molecules have additional motion and exert additional force in the direction in which the wind is blowing. For example, there is an additional pressure towards the east in the case of a west wind. Children should be urged to think of this force as very real. It is exerted by a very real substance—the air—even though it cannot be seen.

Children often ask where the wind comes from. This is a difficult question to answer because its complexity exceeds the comprehension of younger children. Actually, atmospheric movements are produced by the sun's uneven heating of the earth and the surrounding air. This unevenness results from temperature differences in different parts of the world, and at different times of the day and night. Even local temperature differences, such as the difference in the intensity of sunlight on the northern and southern slopes of a hill, play a part. Fundamentally, the energy involved in the air movements is thus seen to be the energy from the sun. When children ask questions about where the winds come from, they can be told that winds are produced on account of unequal heating of the atmosphere by the sun. As they go further in their study of science, they will eventually be able to understand the details.

## 5. WATER IS OBTAINED FROM VARIOUS SOURCES

The importance of water has always exercised the mind of man, from the earliest times to the present day. Man needs water for drinking, cooking, cleaning, and for the irrigation of crops. In hot countries, water also helps people keep cool. In many parts of the world, water is used for transportation. Some parts of the world are uninhabitable because of inadequate water supply; changes in water supply have caused vast migrations of millions of people. Man's ingenuity in finding water, in bringing it to a place where he wants it, and in storing it has been a prime element in the advance of civilization.

### 5(a). SOURCES OF WATER

#### Rain

It is completely obvious to adults that rainfall is an important source of water. Yet children may not appreciate how closely their lives depend upon the occurrence of rains, and that how people strive to preserve rain water. They can be helped to this realization through guided experience.

**Discussion**

**When do we have rains ?**

Ask children to identify months of the year when the monsoons come to their part of the country. Show the rainy seasons on an annual calendar. Now ask children to identify things that happen, particularly on farms in villages, at certain times of the year. Study and discussion of these events—such as planting, harvesting, ploughing, and certain festivals—will show that many of them are closely connected with the annual pattern of rainfall.

**Interview**

**What happens to rain water?**

Encourage children to ask their parents what is done in their town with rain water. They will find that water is often trapped in watering holes, tanks, or behind dams to make it available for months after the rains are over. Sometimes the water is transported from a region where rainfall is heavy to that where natural rainfall is too slight Help children realize that directly or indirectly, rainfall is our chief source of water.

*Collect rain water in a bucket for a day. What is the depth of the water which has been collected?*

**Rivers**

Another source of water is rivers. Often, rivers supply water not only for personal use and for agriculture, but for navigation as well. They get their water directly or indirectly from rainfall or from snow. The importance of rivers to civilization can be made clear to children through the following discussion.

**Discussion**

**Why are most large cities built near water?**

Ask children to name the largest cities they know of. Many of these will be seaports. Help children to look at maps. They can find that whether the cities are on the ocean or inland; most of India's major cities are located on rivers. Explain to the children that the bank of a river is always a good place to build a city, because it is a dependable source of water all the year round.

*On a map, locate the larger, permanent rivers of India. Note that these are the places, including seacoasts, where most of the big cities are situated.*

Man often devises ways of storing rain water for use in times of need. The storing is done by means of mighty dams or artificial lakes. It can also be done in a rural watering hole or in small household storage tanks. Activities such as the following can help children realize the importance of storing water.

**Discussion** **How do we store water?**

Have children consult their parents to find every method they can of making water available when it is *not* raining. Many of these will be natural methods, but focus the class attention on those that are artificial. Help students realize that the ability to store water in lakes, ponds, tanks, and even small jars helps make man reasonably independent of the strictly seasonal supply of water through rainfall.

*Look around the schoolroom and find out what methods there are for storing water even in small quantities.*

**Springs**

Sometimes water naturally flows or seeps from the ground; in some cases it rushes forth with considerable force. Such sources of water are known as springs. Sometimes springs flow only for a few weeks or months after the monsoons; sometimes they flow throughout the year. Usually spring water is cool and clean.

Many children have no first-hand knowledge of springs. They can be helped to understand more about them through experiences such as these.

**Interview** **What do we know about springs?**

Ask children to find out from their parents anything they can about springs. Perhaps older people in the village would be able to tell about springs from their own experience. Have a student tell the rest of the class what he has been told about springs.

*Show pictures of natural springs.*

### 5(b). WE DIG AND DRILL WELLS TO GET WATER

One of man's oldest and most important ways of getting water is from wells. A simple well is just a hole dug into the ground; moisture from the rocks and soil beneath the surface seeps into the well. If it is a good well, the water seeps into it as fast as it can be used. Good wells supply water throughout the year.

The most common type of well is a round hole dug deep into the rock and soil. Usually this is lined with stones or bricks. Sometimes it is lined with concrete. Such wells are deep enough for a good water supply—up to a hundred feet deep, sometimes even more. The water is usually hauled to the surface in leather bags, buckets, or earthen pots, and sometimes a Persian wheel is used. Such wells are the principal source of water in those parts of the country where there is no dependable river or stream.

A more modern kind of well is the tube well. Special machinery is used to drill a hole deep into the rock and soil. This hole may be less than a foot in diameter. A long pipe is fitted inside the hole, and a pump is used to lift the water to the surface. Tube wells are cheaper than dug wells, but they require special equipment. Appreciation of wells can be enlarged through such activities as these.

**Field Observation**

**How are wells prepared?**

If possible, find a place nearby where a well is being dug or drilled. Have the children find out by their own observation how deep the well must go to reach water. Help them find out whether or not the water will be clean, whether or not enough water will be supplied the year round, and how costly it is to dig such a well.

**Interview**

**How long do wells last?**

Ask children to find out from their parents or other older people about their favourite wells. How long ago was the oldest well in the community dug? What has been its record of service?

**Interview**

**How do dug wells and tube wells compare?**

Find out from a local farmer how he and the rest of the community feel about the comparison between dug wells and drilled (or tube) wells. Which is the more costly of the two? Which is the more reliable? Which kind of well is more common among the newer wells of the community?

*With the help of children, try to determine the number of wells in the community and identify which are the oldest, the newest, the deepest, the most dependable, and the most popular.*

## For Better Understanding

Springs and wells are very closely related to each other. The only real difference is that springs are natural, while wells are man-made. Both springs and wells get water from underground sources. This water is present in layers of porous rocks or soil. Water may come through this porous material for many, many miles. However, the water merely seeps through the porous material; it seldom flows, as in an underground river.

One may find underground water almost anywhere in the world, if one digs deep enough. The level beneath the surface where water is found is referred to as the water table. Thus, a spring may be thought of as a place where the water table comes to the surface. A well, however, is an artificial structure which man produces by digging into the earth until he reaches the water table.

## 6. IMPURE WATER

Small children usually take the purity of the drinking water for granted. They are not aware that the water they are drinking may be impure, containing tiny one-celled animals or worms. These impurities can sooner or later cause such serious conditions as cholera and poisoning. Parents usually take care to see that their children do not take impure water.

There are two kinds of materials which may make water impure. One of these consists of poisonous chemicals dissolved in the water. Only rarely are such dissolved materials really dangerous. Water which contains disease-producing micro-organisms is much more common. Sometimes such dangerous water is very cool and clean and sweet to drink.

It is not the intent in this concept to teach children the details of water-carried diseases or the micro-organisms which produce them. Rather, the teacher should try to make children aware of the dangers of using impure water. When children really understand this and other related concepts in science, they are more apt to develop attitudes conducive to good health for themselves, their families, and their communities.

### 6(a). WATER MAY CONTAIN HARMFUL ORGANISMS

Occasionally, children may hear through their parents that some friend or a member of the family has had impure water and is suffering the results. Small children, however, seldom have any real idea of the nature of the impurities or their source. Children in class II usually have no opportunity to see micro-organisms through a microscope. Furthermore, the very nature of germs and their effects makes it impractical for experiments by small children. However, it is possible to bring this matter closer to children's understanding by experiences such as those given on the following page.

**Interview**

**Where can pure water be found?**

Ask children to collect information from their parents or from other adults in the community about impure water. Adults can tell children of cases they know where disease was caused by an impure water supply. Perhaps the adults can tell children of sources of pure water in the community, and also of impure water.

*Tell children about the diseases—dysentery, cholera, and others—which are caused by impure water.*

### 6(b). WATER MAY CONTAIN DISSOLVED SALTS

Almost all water contains dissolved salts and other materials. Only chemically distilled water is free from such impurities. Ocean water contains common salt (sodium chloride) and many other dissolved materials as well. Most natural water also contains dissolved gases; these dissolved materials are not harmful to people. However, salt and other materials may make water undesirable for drinking, and unusable for irrigation. Such dissolved substances are also undesirable when water is used for industrial purposes.

The presence of dissolved materials gives 'pure drinking water' its 'taste'. Water without such dissolved materials tastes 'flat' and unpleasant. Even water with air (including oxygen) dissolved in it has a different taste from the same water when the air is forced out of the solution. Here are some learning activities which can make clear to children the notion that water may contain dissolved materials.

**Investigation**

**How can impurities in water be detected?**

*Materials required*
water sample,
clean glass dish,
mild source of heat

Place in a clean glass dish a shallow layer of the water being investigated. When the water in the dish has evaporated, as in Fig. 2-27, examine the place where it was. Invariably, a thin deposit of material which did not evaporate will be discovered. This material contains the salts that were dissolved in the water; the water has evaporated and left the salts there on the surface of the dish. This investigation can be speeded up by warming the glass dish over a gentle source of heat so that evaporation takes place quickly. If this is done, care must be taken to see that no unwanted material from the flame or its smoke gets added to the water that is being tested.

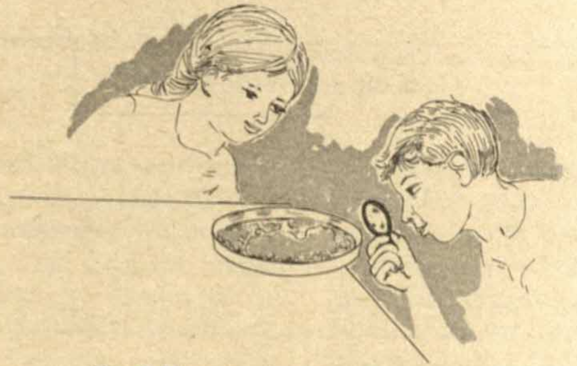


Fig. 2-27
When water evaporates, impurities are left behind.

*Let children taste two samples of water from the same source. One of these should be tasted as it is. The other should be heated to boiling point, then allowed to cool down to room temperature. (Boiling drives out dissolved gases). Compare the taste.*

*Ask children to taste drinking water to which slight amount of salt, sugar, saltpetre, alum, and other similar chemical impurities have been added.*

### 6(c). EVEN CLEAR WATER MAY BE UNFIT FOR DRINKING

There is unfortunately very little relationship between the taste, odour, and appearance of water and the danger it can constitute if used for food and drink. Sometimes water with a peculiar taste or an unpleasant odour is perfectly safe. On the other hand, water which may sometimes seem clean and taste sweet can produce serious or even fatal results. It is difficult to carry on first-hand investigations for this sub-concept. However, verbal activities such as the one below can help children become more familiar with the idea.

**Interview**

**How can unsafe water be identified?**

Invite children to consult the health inspector or a doctor in the community on the question, "How can one identify water which is unsafe for drinking?" Ask children to pay particular attention to whether or not unsafe water can be identified by its appearance. Invite children to share the results of these conversations with others in the class.

*Add a bit of clean sand or a few drops of milk to water. Point out that the appearance of water is usually of little relation to its safety for drinking.*

**For Better Understanding**

There are many kinds of germs or micro-organism which can make water more or less dangerous for drinking purposes. The deathly disease cholera is caused by the presence in water of a specific micro-organism—a kind of bacteria. This is present sometimes in other foods too.

Certain kinds of amoeba present in drinking water may produce amoebic dysentery. This is a disease of the digestive system the presence of which can go undetected for months or even years. By the time the disease is discovered it is usually very difficult to cure it.

Most impure water, however, produces only mild and temporary digestive upsets. Some people seem to regard such digestive discomforts as 'almost normal'. Even though the immediate results may not be really serious, such water makes a person repeatedly weak and 'tired'. In many cases, this condition reduces the general health of a person that may cause in turn some other more serious diseases.

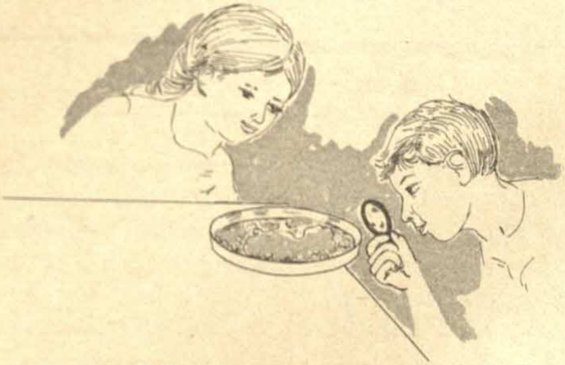
## 7. WATER IS CONSTANTLY UNDERGOING CHANGE

Children often regard water as a very permanent, stable thing. The ocean is 'always there', and so are large lakes and rivers. Rain is seasonal but fairly dependable. Deep down, the ground is always moist and good wells provide water throughout the year. Clouds are distant and somewhat mysterious to children. Most clouds seem unrelated to rain, or to any other kind of moisture. Clouds come and go and often change shape. Most children seldom notice that they get larger or smaller. Little wonder that children often ask where the rain comes from!

As children acquire better and better understanding of this concept about the constant change of water, they can begin to see the relationship between water 'drying up', the formation of clouds, and the source of rain. Thus, they can begin to acquire knowledge which will eventually lead to an understanding of the water cycle.

### 7(a). EVAPORATION TAKES PLACE AT ALL TIMES

Children have already been exposed to the idea of evaporation of water (see major concept 1 of this unit). Already they know that water does not simply 'dry up and disappear', but changes its form from liquid to water vapour. Already they know that evaporation occurs more rapidly under certain conditions. What they do not realize is that some water evaporates no matter what the conditions are. They can be helped to this realization by the following activities.



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**Discussion**

**Does evaporation take place on all days?**

Engage children in a discussion on when water evaporates most easily—and least easily. Challenge them to find situations where water does not evaporate. They may say that it does not evaporate on a rainy day or on a cold day. Help them investigate these situations through experiments. Help them realize from their observations that on rainy days or cold days evaporation is slower but it still occurs.

*Spread wet clothing out to dry on a rainy day, but not in the rain. Note that it dries, although slowly.*

### For Better Understanding

Actually, the rate of evaporation depends, among other things, on the amount of water vapour already in the surrounding air. If the surrounding air already contains all the water vapour it can hold under existing conditions (of temperature and pressure) then no more water vapour can come into the air, so there is no net evaporation. In the final analysis, there is still evaporation taking place under these extreme conditions, but the rate of evaporation is exactly equal to the rate of condensation. That is, evaporation and condensation are in equilibrium.

### 7(b). CLOUDS ARE FORMED FROM EVAPORATED WATER

Clouds contain water. This water comes from water vapour in the air—that is, water which has evaporated from the ocean, lakes, rivers or moist soil. The conditions under which clouds form are extremely complex. However, it is possible for children to get the general idea of cloud formation through first-hand activities such as these.

**Investigation**

**What makes the cloud above boiling water?**

Arrange to boil some water in a pan. As the water boils vigorously, have children notice the cloud that forms above the water. Ask them to explain the source of this. Actually, the cloud is condensed from the water vapour which is produced by the boiling water.

**Familiar Experience**

**Why do we sometimes see our breath?**

Have children recall that their breath turns into mist or cloud on a chilly day. Ask them to explain the source of the cloud. They are likely to say that it comes from their warm breath. This is only partly true. Actually, the cloud is produced from the water vapour in their warm, moist breath.

*Urge children to observe the cloud or mist (not smoke) which rises above pots of boiling water in the kitchen at home.*

### For Better Understanding

Clouds formed in activities above are genuine clouds. They consist of microscopic droplets of wet, liquid water. It is improper to refer to clouds as water vapour or as steam; a much better term is 'mist', although the droplets of water in a cloud are much smaller than those in a typical mist The teacher should remember that both water vapour and steam are quite invisible; this will help in deciding the proper term to use when discussing this subconcept.

### 7(c). RAIN COMES FROM CLOUDS

Small children often realize that rain comes from clouds. Once children realize that clouds contain water, they are more than ever convinced of the relationship between clouds and rain. The fact that not all clouds provide rain is confusing to children. Rain-from-clouds is a very complex process, not completely understood even by professional meteorologists. It is possible, however, to provide children with first-hand observations which can give them a general idea of how rain comes from clouds.

**Investigation**

**How does water form from water vapour?**

*Materials required*
pan,
water,
source of heat,
cool shiny surface

Arrange a pan of boiling water in such a way that the cloud which forms over it comes in contact with a cool surface. This surface may be a piece of glass or a shiny pan with cool water in it. Invite children to observe the water which forms on the cool surface, as in Fig. 2-28. Ask them to consider where this water comes from. It has, of course, come from the water which has evaporated from the pan.

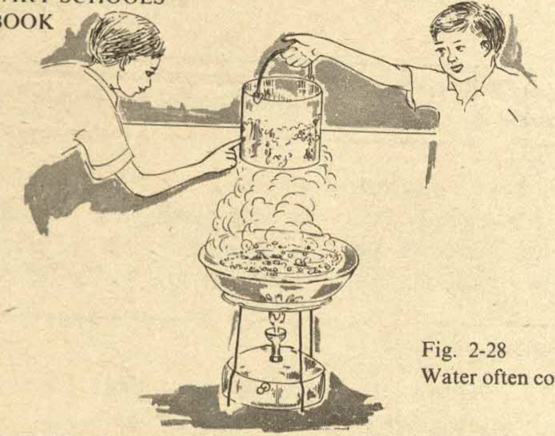


Fig. 2-28
Water often condenses on cool surfaces.

**Investigation**

**How can we collect moisture from breath?**

*Materials required*
cool shiny object

Invite children to breathe gently on a a cool object, such as a shiny metal jar. Under favourable conditions they can see moisture formed on the surface as in Fig. 2-29. Challenge them to tell from where this moisture has come. Its source, of course, is the moisture in the breath.

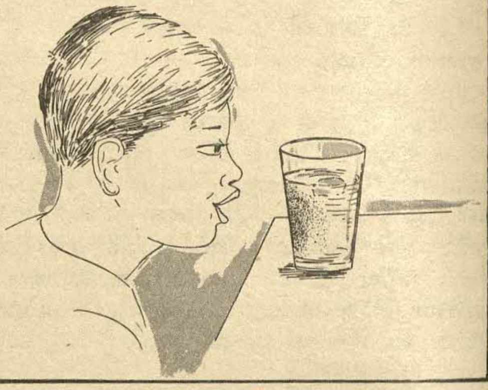


Fig. 2-29
Moisture from the breath often condenses on a cool surface.

*Observe the formation of moisture on cool surfaces, such as window panes, drinking glasses, water pitchers.*

### For Better Understanding

The activities above are really demonstrations of the formation of dew, not rain. Strictly speaking, dew forms when water vapour condenses on cool surfaces. Rain, on the other hand, forms from clouds (which are *not* water vapour) and forms in the air—usually right inside the cloud. However, the formation of rain is extremely difficult to demonstrate without very complex equipment. The activities above are useful to show the general idea of rain formation, even if they are not exact models of the true rain-forming process.

Water forms on cool surfaces in two different ways. When water contacts a sufficiently cool surface, it condenses into liquid water on that surface. This is the formation of water from invisible water vapour. When a cloud—which is droplets of wet water—contacts a cool surface, some of its water remains on the surface. In a situation like that in Fig. 2-28, both of these actions contribute to the formation of water on the cool surface. If this is discussed with children, the teacher must take care not to confuse a 'visible cloud of water droplets' with 'invisible water'. Actually, clouds also contain invisible water vapour *among* the tiny droplets of water.

### 7(d). SOME RAIN WATER SINKS UNDERGROUND

"Where does the water go when it rains?" is a common children's question. Already children know that some of this water evaporates. However, an important fraction of rain water soaks into the ground. Some of it thus provides water for immediate use by the roots of plants. Some of it remains far beneath the surface of the soil (see major concept 6 above). Here are some first-hand observations which can help children become familiar with this sub-concept.

**Investigation**

**How does water enter the soil?**

*Materials required*
clear glass jar,
dry sand or soil,
water

Fill part of a glass jar with dry sand or soil. Have a child slowly pour in some water as in Fig. 2-30. The water is seen to moisten the top of the soil sample and then disappear. Ask children where the water goes. Invite them to examine the sides of the jar as more and more water is added. Soon they can see that the water which has disappeared from the surface is actually accumulating some distance below.

Fig. 2-30
Surface water seeps into dry soil.

**Field Observation**

**How does irrigation water get to the plant roots?**

Visit a farm plot where irrigation is being done. Ask children to consider where the water, which is being supplied to the soil by the farmer, goes. Their answers will contain the idea that the crops that are being grown have used up the water. While this is true, help them realize that the water must first seep into the soil. This idea becomes more clear when children can dig a short way into the irrigated soil and see that the water has penetrated some distance below the surface.

*Observe rainfall during the monsoon. While much of the rain water flows away, some of it seeps into the soil.*

### 7(e). SURFACE WATER FLOWS TO RIVERS AND THE SEA

Children have learned through earlier experiences that some water evaporates and that some soaks into the soil. However, much of the water from rains flows into streams and rivers and from there to lakes and into the ocean. It is possible through direct observations to help students understand this sub-concept.

**Familiar Experience** **Where does rain water go?**

Ask children to recall what happens to all the water that comes as rains. Some of it gathers into tiny streams and flows along the streets and roads, perhaps into a brook or a river. If the school is near a river, help children remember how the river increases in size when the rains begin. Help them realize that the swollen river is carrying rain water to the sea. Help them look at large and simple maps to see how the Ganges or the Indus or the Jamuna carries water to the sea.

*Identify nearby streams and rivers, whether seasonal or permanent, with the help of a map, and show how they eventually pour their water into the sea.*

### 7(f). UNDERGROUND WATER PROVIDES SPRING WATER OR WELL WATER

Some of the water which seeps into the ground soon finds its way to the roots of plants, or it creeps back to the surface of the soil where it evaporates. However, an important part of the water which soaks into the soil sinks down many, many feet—often hundreds of feet. At these levels it seeps along through porous layers of soil or of rock. It is this enormous underground water supply which provides water for springs and wells. First-hand experiences to help children understand the nature of underground water are found in major concept 6 of this unit.

### For Better Understanding

The big idea under discussion in this major concept is often termed the 'water cycle'. Water which falls on earth as rain or snow can do one of these three things —evaporate, run off in rivers and streams, or soak into the earth. In any event, the water eventually does evaporate, and becomes water vapour in the atmosphere. Some of this water vapour condenses as dew or frost, but most of it eventually goes to form clouds. From the clouds it comes back to the earth as rain or snow thus completing the water cycle.

While this terminology and this complete concept are too advanced for class II students, it is useful for the teacher to know the underlying principle of the water cycle, and to understand the direction in which to guide students' conceptual development.

### Scientists at Work

### Scientists believe in the principle of cause and effect

For thousands of years most people believed that the events of nature 'just happened'. Clouds appeared—or did not appear—in the sky 'because that's the way clouds are'. The cycle of seasons occurred year after year 'because it was natural for them to do so'. Sometimes the monsoons were good and people were prosperous and happy. At other times the rains were poor, and many people suffered and died for lack of food and water. These kinds of natural disasters were thought to be unavoidable—when they happened, they happened—maybe from sheer chance, or possibly because some group of people had behaved improperly. But these are the thoughts of non-scientific people.

Today there are still many people throughout the world who believe that weather and climate 'just happen'. But modern people are coming to believe more and more that every effect has its cause or causes. There are physical reasons why it rains or doesn't rain, when storm occurs, or when crops fail. A scientific point of view includes the belief that every effect has its cause or causes.

Scientists do not believe that natural disasters occur because someone is mad at the people, or because the people have been wicked. Rather, scientists believe that these natural disasters occur because of a set of natural causes, even though the causes may be very hard to understand. Scientists do not believe that people must for ever live in helpless fear of flood and famine, of disease and disaster. Rather, they believe that people can study to understand their environment, and can learn to live with it or modify it, predict it, and in some cases, even control it. This all comes from believing in the principle of cause and effect.

You don't have to be a scientist to believe in the principle of cause and effect. Every boy and girl and man and woman can share this scientific point of view.

# UNIT 2

# AIR, WATER AND WEATHER

## CLASS III

### Overview

Man lives at the bottom of an ocean of air. He interacts with this air, and is completely dependent on it. Only a few men live so close to an ocean of water. Yet water is an important part of air, and man is completely dependent on water also. Weather may be thought of as the overall condition of the atmosphere at any one time and place. This condition includes, among other things, the movements of the air and the amount and kind of water which it contains. The weather condition also includes the temperature of the atmosphere. So air, water and weather are all related to one another. Individually and collectively, these conditions greatly influence the activities of people and of all other living things. It is desirable that primary school children devote some time to study these areas of science during each year.

At earlier class levels children have learned about the great variety of weather, as also some of the conditions which go to make weather. They have learned about what air is, what it may contain, and where it may be found. They have also learned the importance of water to man, its sources, its impurities, and some of the changes it undergoes.

At class III level, there are four important ideas, treated in the five major concepts of the syllabus. They are:

1 Water can exist in any one of the three states, and may be converted from one state to another.

2, 3 There are many kinds of weather; the pattern of weather is constantly changing.

4 Thermometers are used to measure the intensity of heat. This measurement is made in degrees.

5 Weather affects man in many ways.

The first (three forms of water) and the fourth (measurement of temperature) of these concepts are basic to further understanding of air, water and weather, and should be given special attention. The other three are more descriptive in character and will be easier for students to comprehend. Some teachers therefore like to work first on the first and the fourth concept.

### 1. WATER EXISTS IN THREE CONVERTIBLE FORMS

Adults know that under proper conditions, liquid water can be converted into ice, or into water vapour and that the reverse changes are also possible. However, children often fail to see the relationship between these three forms of water. Rather, they often think of ice not as 'water in solid form' but as something quite different from water. Children often give very little attention to water in the gaseous form—such as water vapour or steam. While children may associate ice with coldness, and water vapour or steam with warmth, they have no understanding of the energy relationships involved in the three forms of water.

In teaching this concept at this class level it is enough to help children understand that water can exist in three forms, and that the changes from one form to another can be controlled. This will provide a solid basis on which to build other concepts in later years—concepts about the molecular theory of matter and about the energy relationships among the three forms of matter.

### 1(a). ICE MELTS AND CHANGES INTO WATER

Although children are aware that ice melts, they often know nothing of the details of the melting process, nor do they know precisely what is left after ice has melted. Students can be helped towards a more thorough understanding of the melting process through such personal experiences which require careful observation.

**Investigation**

**What happens when ice melts?**

*Materials required*
clean ice container
(preferably glass)

Obtain a few pieces of ice which has been made from clean (drinkable) water. Arrange for the ice to melt under such controlled conditions that the class can make careful observations as in Fig. 2-31. Here are some of the observations that children can be encouraged to make:

1. Ice is cold, no matter how small its pieces are, or how long it has been melting.
2. Ice begins to melt only at the surface, never from inside.
3. Ice melts faster when it is exposed to heat than when it is kept cool.
4. The weight of a chunk of ice is the same as that of the water formed when it (ice) melts.
5. Ice floats on water.
6. Ice requires time to melt; it does not melt instantly.
7. The liquid left when clean ice melts into water is no different from other samples of clean water.

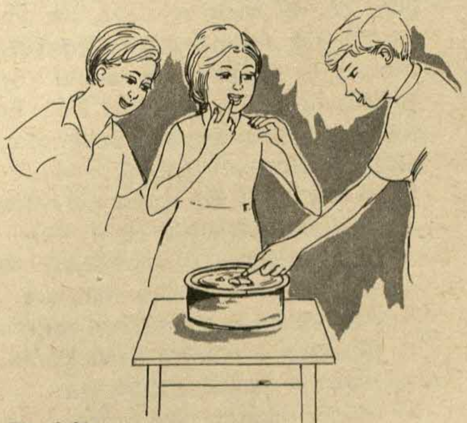


Fig. 2-31
The changing of ice into water is important and interesting.

In discussing these observations with children, help them understand that ice and water are merely different forms of the same material, that melting is a process which requires a supply of heat.

*Display pictures of glaciers or snow fields or icebergs melting to form streams and rivers. Show or draw pictures of a block of ice before and after it melts.*

### 1(b). WATER FREEZES AND CHANGES INTO ICE

Many children have never had any experience of how water freezes and changes into ice. If a refrigerator is available, this process can be shown, or it can be shown in winter in parts of the country where it is very cold. If there is a supply of ice available, it can be used with salt to freeze water into ice. From the following activities children can, with careful observation, learn a great deal about the process of freezing.

**Investigation**

**What happens when water freezes?**

*Materials required*
clean water,
pan,
refrigerator or salt
and ice mixture

If a refrigerator is available, or if the weather is cold enough outdoors, freeze some clean (drinkable) water into ice. If necessary, use ice and salt (in the manner of an ice-cream freezer) to freeze water under controlled conditions as in Fig. 2-32. Encourage children to make observations such as these :

1. Water must get very cold before it freezes (changes into ice).
2. The colder the conditions, the quicker water freezes into ice.
3. The weight of a sample of water is the same as that of the ice formed when it (water) freezes.
4. Water requires time to freeze into ice—freezing does not occur instantaneously.

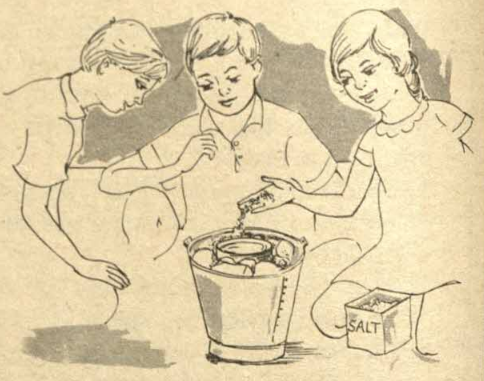


Fig. 2-32
Water freezes to form ice—liquid changes into solid.

5. The ice formed, when clean water freezes, can melt to form clean water again.

While discussing these observations with children help them understand that ice and liquid water are the same material (water), but in different physical forms. Help them begin to accept the idea that freezing is a process during which heat is taken away from water. Relate this to the sub-concept and the activity 1(a) of this major concept.

*Display pictures of a lake or pond before and after it freezes. Visit an ice-making machine or plant if there is one nearby.*

### 1(c). WATER EVAPORATES AND CHANGES INTO WATER VAPOUR

From work in earlier classes, children are already familiar with the process of water evaporation—water changing into water vapour. They know that evaporation takes place better when it is warm, and when the surrounding air is dry. They have already carried out activities related to this sub-concept. If necessary, some of these activities can be repeated. Or it may be enough simply to discuss with the class in detail the observations which were made from these activities. Here are some of the principles which should be brought out either through new observations, or from fresh discussion of previous observations.

**Discussion**

**What happens when water evaporates?**

1. When water changes into water vapour, it becomes invisible.
2. Evaporation is a time-consuming process, it does not occour instantly.
3. Under ordinary conditions, evaporation takes place from an exposed surface, not from the interior of a sample of water.
4. When water evaporates, materials dissolved in it are left behind.
5. When water evaporates, it takes heat from its surroundings, and thus makes them cool.

While discussing these observations with children, help them realize that liquid water and water vapour are merely different forms of the same material (water), also that evaporation is a process which requires heat energy.

*Display pictures of the forms of water before and after evaporation.*

*Visit or describe a lake or a pond that becomes dry within a few months after the monsoons.*

### 1(d). WATER VAPOUR CONDENSES AND CHANGES INTO WATER

At earlier class levels, children have had experiences of how water vapour condenses into liquid water. Now, however, the emphasis is on the nature of the physical change involved in condensation. Activities such as those which follow can help children become better acquainted with the change involved in condensation.

**Investigation**

**What happens when water vapour condenses?**

*Materials required*
clean bucket filled with cold water, pan, salt or sugar

Arrange for condensation to occur on a cool, clean surface, such as the outside of a glass or metal container filled with cold water. The water inside the container may be mixed with salt or sugar. Have children observe the formation of mist on the cool surface. Challenge them to tell from where this has come. Let them taste it to see whether or not there is any flavour of salt or sugar in it. Allow the condensation to run down the sides of the container to be caught in a clean, shallow pan. Ask children to study this condensed material, feel it, and taste it. Throughout this activity, help them make observations such as these :

1. Water which condenses from water vapour is clean and clear.
2. Condensation takes place better on a cool surface.
3. When water vapour condenses, its result cannot be distinguished from any sample of pure water.

**Investigation**

**How is water distilled?**

*Materials required*
pyrex (heat resistant) flask, one-hole rubber stopper to fit flask, short piece glass or metal tubing, rubber tubing, slender bottle or test tube, glass jar, water, salt or sugar, source of heat

Arrange a boiling flask, a connecting tubing, a slender bottle, and a vessel of cool water, as indicated in Fig. 2-33. Boil water in the flask and allow steam and hot water vapour to flow into the slender bottle which is dipped in cool water. Have children observe the water which appears in the bottle. Challenge them to say from where it has come. If they believe that some of the water from the flask has 'splashed over' into the slender bottle, encourage them to repeat the investigation with some salt or sugar mixed in the boiling flask. Let them taste the water collected in the bottle and indicate its source. The investigation may be repeated with the bottle *not* in the water. Have children note that the bottle now becomes very hot and that condensation is very much less than it was before. Encourage children to make observations such as these:

1. During condensation, water vapour (and steam) change into liquid water.
2. Water condensed from water vapour and steam is just like other water, except that it contains no impurities.
3. Condensation warms the surface (sides of the bottle) on which it occurs.
4. Condensation provides (gives off) heat energy.

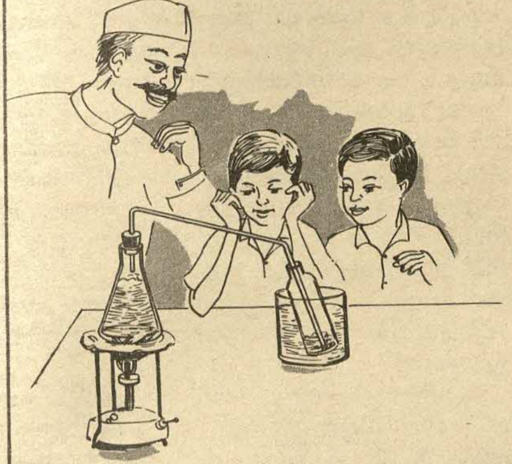


Fig. 2-33

In distillation, water is boiled and re-condensed under controlled conditions.

In discussing either or both of these activities with children, try to relate the process of condensation with that of evaporation. Help children realize that these processes are physical opposites. Help them see that while evaporation requires heat, condensation gives off heat. Help them realize that liquid water, water vapour, and steam are all forms of the same material—water.

*Discuss uses of distilled water, as in automobile batteries (accumulators) and in chemical laboratories. Distilled water is also used to dilute penicillin before it is injected.*

*Call attention to kitchen walls and windows which collect mist (dew) when it is cold outside. Dew is liquid water condensed from water vapour.*

### For Better Understanding

It is important that teachers know something of the overall understanding of the concepts towards which children's learnings are directed, even though it is not to be achieved at this class level.

Under proper conditions, most materials can exist in a solid, in a liquid, or in a gaseous form. Water, the most common and familiar compound, offers a splendid example. These three forms of matter—solid, liquid, and gas—are known as 'states of matter'. Children can also be told of such other changes of state, as when paraffin melts, or when petrol evaporates. The change of state is a purely physical change; there is no change of the molecules themselves, their arrangement and their relation to each other. In water, the molecules are $H_2O$.

Energy is involved in these changes of state. Energy is *required* to change ice into water, or water into water vapour or steam. This energy is in the form of heat. On the other hand, energy is *given off* when the change of state is in the opposite direction, from vapour or steam into liquid, and from liquid into solid. This energy is given off in the form of heat.

Water vapour and steam are closely related. Both are invisible, both are dry (that is, unlike cloud or mist, they contain no *liquid*, wet water). Both are formed by water changing from liquid into a gaseous material, and each can be condensed back into water. The difference between steam and water vapour is a technical one. The term 'steam' is properly used for gaseous water which is much hotter than boiling temperature, while 'water vapour' refers to water near or below the boiling temperature. Strictly speaking, steam behaves like a true gas, while water vapour does not. While this is not important for children, it is important that they realize that steam and water vapour are invisible and gaseous, while clouds and mist are visible and consist of tiny droplets of liquid, wet water.

In higher classes, children will learn more and more about changes of physical state, not only of water, but of certain other materials as well. In this class, only the beginnings of this important concept are learned. But if children really understand these simple beginnings, it will be easier for them to understand more advanced concepts in higher classes.

## 2. THERE ARE MANY KINDS OF WEATHER

While studying this unit in earlier classes students learned about the endless changes in weather. The concepts in that part of the syllabus were simple, and students were simply made aware that there is a variety in weather. Here in class III students are ready to be more specific about different kinds of weather, and begin to learn about their causes.

### 2(a). THE SUN, WIND, CLOUDS AND RAIN DETERMINE WEATHER

"What goes to make up the weather." This is a good question with which to begin a study of this concept. Many people are content to say simply that weather is 'fine', or that it is 'unpleasant'. By the term 'weather', some people merely think of temperature, rain or wind. A good way to focus children's attention on 'what goes to make up the weather' is through discussion, such as this.

**Discussion**

**What features make up weather?**

Ask children what they think weather is. List on a black-board all responses children have. Such items as these will be mentioned:

| | |
|---|---|
| temperature | condition of sky (cloudy or clear) |
| visibility | brightness and warmth of the sun |
| direction and speed of wind | rainfall |

Help children realize that 'weather' is a complex term, and has many aspects. Also try to stimulate their curiosity about what causes changes in these aspects of weather.

*Display pictures of typical kinds of weather, both local and from other parts of the world.*

*Encourage children to make drawings of different kinds of weather they can remember.*

**2(b).** IT IS WARMER IN THE DAY-TIME THAN AT NIGHT

Children know that it is cooler at night than in the day-time. Sometimes children suggest that the sun is not shining because it is night. They fail to realize that it is the lack of sunshine which produces night. Lack of sunshine is the cause, not the effect, of darkness. Similarly, they may fail to see the relationship between the sunshine and the coolness of the night. Such observation and discussion as suggested below will help children towards this understanding.

**Discussion**

**Why are days warmer than nights?**

Ask children to tell which part of the twenty-four-hour-day is the warmest, and which is the coolest. They will probably suggest that afternoon is the warmest, and very early morning the coolest. Help them to simplify this response and say that it is warmer during the day-time and cooler during the night. If possible, have one or more students use a thermometer for several days and nights continuously to measure rather than merely estimate temperature conditions. Try to focus children's attention on *why* night is cooler. Help them realize that it is not merely because it is night, but because there is no sun to warm this part of the earth at night. See also the next sub-concept.

*Use a thermometer to measure temperature in the morning, the afternoon, the evening and the night. Discuss the results with the class.*

The teacher should also consult the section "For Better Understanding" at the end of this major concept.

**2(c).** IT IS WARMER IN THE SUNSHINE THAN IN THE SHADE

Children know that it is warmer in the sun than in the shade. Indeed, it is well to remind them that this is one of the many things they have learned for themselves, not by being told by some adult or through reading a book! However, they seldom have any idea *how much* warmer it is in the sun than in the shade. Here are activities which can help them find this out.

**Investigation**

**How well can the body detect changes in temperature?**

*Materials required*
cloth for blindfold

Let a child lead a thoroughly blindfolded child from a sunny to a shady part of the school yard. Ask the blind-folded child to say whether he is in the sunshine or the shade. On the basis of his reply, challenge other children to say how promptly the blind-folded child can detect a distinct change in temperatre. If possible, let a child or a group of children use a thermometer to measure the temperature in the sunshine, and in the shade. Have the observers report on the degree of the temperature difference. Relate what they have found in sub-concept 2(b) above.

*Observe where people and other animals rest on a hot, sunny day.*

*Ask children where they prefer to sit and listen to a story if it is to be outdoors.*

### 2(d). IT IS WARMER WHEN THE SUN'S RAYS ARE OVERHEAD THAN WHEN THEY ARE SLANTING

Children usually realize that early morning and late evening are the coolest parts of the day. However, they often assume that this is so merely because it is morning or evening. They should be helped to realize that it is the different angles of the sunshine that cause these temperature differences. Here are activities which can help them see this relationship.

**Investigation**

### How does temperature vary throughout the day?

*Materials required*
protractor (if possible),
material to make chart,
thermometer (if possible)

Have a group of children describe temperature differences throughout a typical day. A thermometer is helpful, but not necessary. Help them make a graph or a chart showing time of the day plotted from left to right, with a curve or broken line whose height indicates the temperature, something like that in Fig. 2-34a. The group can then show on the same chart (Fig. 2-34b) the angle of the sun's rays from the horizon throughout the day. The 'angle of the sun's rays' can be thought of as 'how high the sun is in the sky'. From such a chart, children can be helped to see for themselves that the temperature is usually high when the sun is nearly overhead, and that it is cooler when the sun is near the horizon and its rays strike the earth from a low angle.

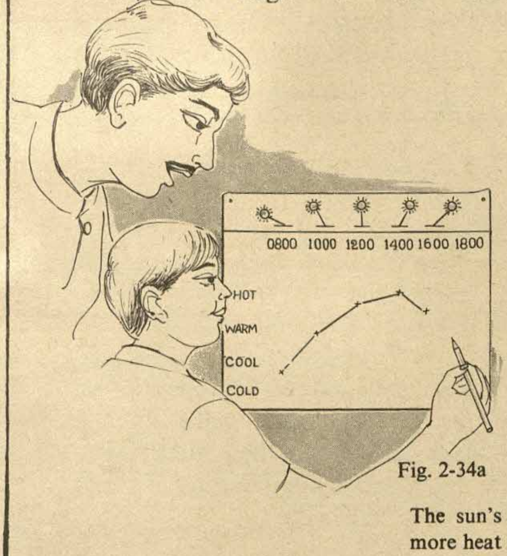


Fig. 2-34a

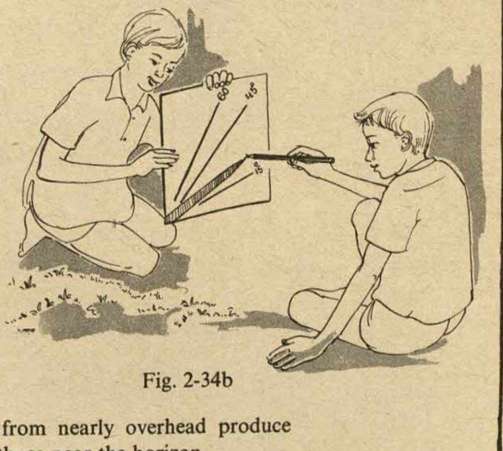


Fig. 2-34b

The sun's rays from nearly overhead produce more heat than those near the horizon.

*Let torch-light fall perpendicularly on a wall, then at an angle. The torch should be at the same distance from the wall in both cases. Have children notice that the wall is more brightly lit in the case of direct rays, and more dimly lit in the case of slanting rays.*

The teacher should also consult the section "For Better Understanding" at the end of this major concept.

### 2(e). DAYS MAY BE WINDY OR RAINY OR CLOUDY OR MORE THAN ONE OF THESE

Many children—and adults too—often describe weather simply as being 'cool' or 'rainy'. They should be helped to realize that weather is really a combination of many factors. Well-selected activities can help children realize this.

**Class Project**

**Let us keep a record of weather**

*Materials required*
material to make
a weather chart

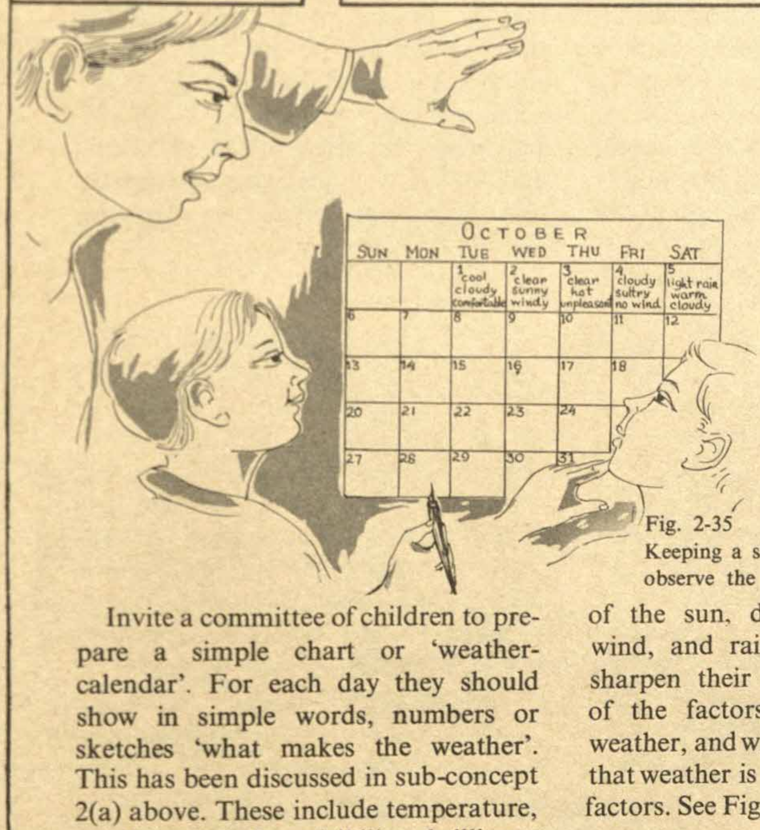


Fig. 2-35
Keeping a simple weather chart helps children observe the various aspects of daily weather.

Invite a committee of children to prepare a simple chart or 'weather-calendar'. For each day they should show in simple words, numbers or sketches 'what makes the weather'. This has been discussed in sub-concept 2(a) above. These include temperature, condition of sky, visibility, brilliance of the sun, direction and speed of wind, and rainfall, if any. This will sharpen their powers of observation of the factors which make up the weather, and will also help them realize that weather is a combination of many factors. See Fig. 2-35.

*Challenge children to name as many different kinds of weather as they can. Which of these can occur in combination with others?*

### 2(f). CLOUDY NIGHTS ARE WARMER THAN CLEAR NIGHTS

Most people realize that cloudy days are usually cooler than clear days. They know that this is because clouds shield the earth from the sun's heat. Many people also assume—incorrectly—that cloudy nights are also cooler than clear nights. Actually, a cloudy night is usually warmer than a clear night. This is true because clouds act like a shield to prevent the earth from losing heat by radiation. While the detailed reasons for this situation are beyond the understanding of class III children, they are at least old enough to notice that cloudy nights are apt to be warm. Here is an activity which can help them make this observation.

**Class Project**

**Which are warmer—cloudy nights or clear nights?**

*Materials required*
thermometer (if possible)

Ask a group of children to keep a record for several weeks of the temperature at a certain time—say, 6 o'clock—each morning. They should also note whether the sky is cloudy or clear each night. A thermometer is helpful, but is not absolutely necessary. An examination of this record will show that although there are exceptions, cloudy nights are in general warmer than clear ones.

*In a discussion, compare a layer of clouds at night with a layer of blankets. The blanket of clouds helps keep the earth's heat from escaping, just as a blanket helps keep the sleepers' body-heat from escaping.*

### For Better Understanding

Noon—when the sun is highest in the sky—is not the hottest part of the day. This is true because time is required to heat up the earth which has cooled off during the night. For the same reason, June 21, when the sun is highest in the sky and when the day is also the longest, is not the hottest day of the year. Several weeks later the days are hotter still, since the earth has had to take time to warm up with its daily exposure to sunshine.

Also, midnight is not the coolest part of the night, nor is December 21 the coolest time of the year. For several weeks after December 21 (the shortest day of the year) the earth continues to lose heat faster than it absorbs it. During the night, the earth continues to lose heat long after midnight until the time the sun actually rises.

If children bring up these points, they can be explained simply and briefly. If these points are not mentioned, there is no need for the teacher to introduce them at this class level. However, the teacher should understand this temperature-lag situation, as it may seriously affect the observations children make in the activities of sub-concepts 2(b) and 2(d).

## 3. WEATHER CHANGES

Children have already learned in class I that there are variations in weather, and that weather changes from time to time. In class III, they will now have a chance to see under what conditions weather changes, and to learn more about the details of weather patterns.

### 3(a). WEATHER MAY CHANGE FROM DAY TO DAY, AND FROM TIME TO TIME

There is not much of a regular pattern in changes of weather. They may occur during the day or during the night, or they may occur over a period of several days or even weeks. Weather may not change every day, but on some days there may be two or more marked changes in it. Activities like the following will help children understand this concept.

**Class Project**

**Is there any pattern in changes of weather?**

*Materials required*
material to make
a weather chart

Encourage a group of children to observe weather and record their observations on a simple 'weather-chart' or 'weather-calendar', as suggested under sub-concept 2(e) above. Have them pay particular attention to *when* weather changes. They may be surprised and interested to learn that the pattern of weather does not always change 'between days' (at night). Rather, they will find that the change in weather occurs sometimes during the night, and also sometimes during the day-time. Furthermore, weather does not necessarily change every day. Also, have children look for long-range changes in weather, those happening over a period of several days or weeks, as during marked changes of a season.

*Discuss with the class when was the last change in weather they can remember? What was the change? Encourage them to predict the next change. To what extent are their predictions accurate?*

### 3(b). WEATHER MAY CHANGE DUE TO A STORM

Some weather changes occur at the beginning or the end of a storm. Often the monsoons are preceded by a gradual increase in cloudiness. Then one day the wind may get very strong and blow a great deal of sand and dust into the air. Within an hour or so the long-expected rains have arrived. Smaller, shorter rainstorms are often introduced by a marked change in weather. Here is a discussion-type activity which can help students understand this kind of a weather change.

**Field Observation**

**What is the weather like just before a storm?**

Ask children to recall the conditions at the beginning of the last storm they saw. If this unit is taught at a time when there are storms, try to have the class as a group observe a storm carefully. Note in particular the change that weather undergoes with the beginning of a storm. It may be a dust storm or a rainstorm. There are changes in the sky, in the wind, and in the temperature. Perhaps some children can recall stories told by their parents about unusually severe storms.

*Invite children to observe weather outside very carefully. On the basis of the present weather do they predict a storm? Help them analyze the way in which their prediction is based on their observation of the present weather.*

### 3(c). WEATHER MAY CHANGE WHEN THE DIRECTION OF THE WIND CHANGES

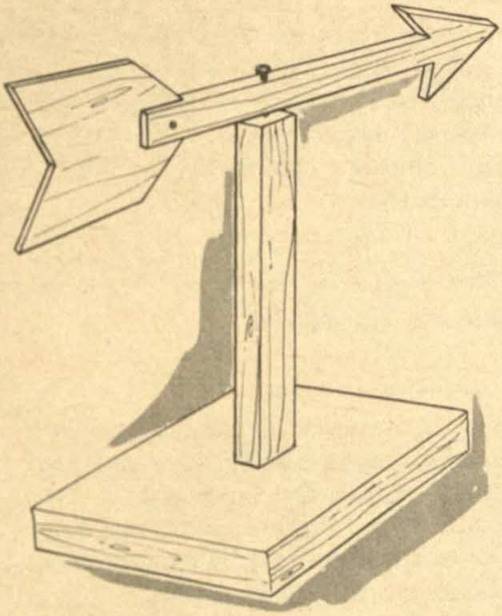
People who live and work outdoors—people such as farmers and sailors—often learn to expect changes in weather when there is a change in the wind. The 'rules' which seem to relate changes in the wind to changes of weather vary greatly from one part of the country to another. One learns about these either by a careful first-hand observation, or by listening to more experienced persons who are familiar with these things. Here is a construction-type activity which can help students observe changes in the wind direction.

**Construction**

**Can we make and use a wind-vane?**

*Materials required*
wood, nails,
cardboard,
simple hand tools

Help children construct a simple wind-vane from wood or cardboard, as



suggested in Fig. 2-36. If this is not possible, show children how to determine wind direction by watching smoke, or by throwing a handful of dirt up into the air. Encourage them to keep careful records of the wind direction several times a day for a few weeks. The wind direction can be studied in terms of the 'weather-calendar' described above. Often students will find that distinct changes in weather are accompanied by changes in the wind.

Fig. 2-36
A simple wind-vane makes weather observations more complete and more interesting.

*Ask local farmers if they have any 'rules' to associate wind changes with coming rain.*

*Ask local farmers to help identify the prevailing winds at different times of the year.*

**For Better Understanding**

Weather science is a very complex subject, and the prediction of weather is a skill which requires a great technical understanding and much special equipment. Teachers and students should not expect to become competent weather forecasters. Rather, at the elementary school level, it is desired to make children aware of the pattern of changing weather, of the general cause for weather conditions, and of the complicated and useful work done by the professional metereologists.

### 4. A THERMOMETER IS USED TO MEASURE TEMPERATURE

Children in class III often have had some experience with thermometers. Several of the science learning activities already recommended in these pages suggest that children actually use thermometers. So far, however, thermometers have been considered simply as useful measuring devices; no attention has been given to *how* they work. Under this major concept, children will be introduced to the principles on which thermometers operate.

### 4(a). WHEN TEMPERATURE GOES UP, IT CAUSES LIQUIDS TO EXPAND AND RISE IN THERMOMETERS

Almost without exception, solids, liquids and gases expand when they are heated and contract when they are cooled. The most common kind of thermometer operates because a liquid expands and contracts with changes in temperature. This change in liquid volume makes the liquid move in a very fine tube and thus makes the temperature readable. The liquid may be mercury, which is silvery in appearance. Or the liquid may be alcohol, which is usually coloured either red or blue to make it visible. The hollow tube is extremely fine—often finer than a hair! In the activities that follow, coloured water is used for liquid, and the thermometer vessel is made from a bottle and an ordinary glass tubing.

**Investigation**

**Can we make a model thermometer?**

*Materials required*
bottle,
one-hole stopper,
glass tubing,
coloured water

Arrange a model thermometer as suggested in Fig. 2-37. It is important that this be arranged while the children watch and help, where possible. The activity is much less meaningful if the equipment is assembled in advance and merely shown to the class.

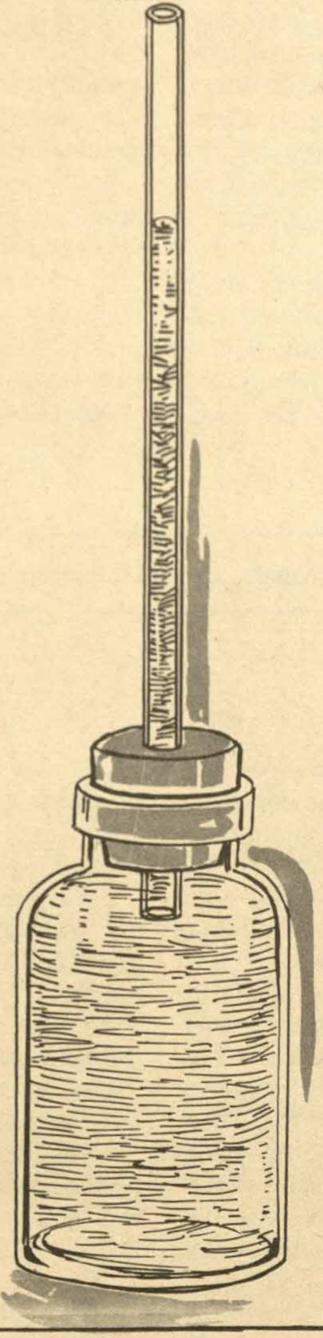
To assemble the equipment, fill the bottle completely with coloured water. The glass tubing is inserted in a one-hole rubber stopper. The stopper is then forced into the bottle. This action forces the coloured water up in the tube.

If these materials are not available, they can sometimes be improvised from soda straws or other near-transparent tubing. This can be fitted into a hole drilled in a cork, and sealed with melted paraffin.

When the demostration thermometer is warmed, the water expands and rises up in the tube. When the thermometer is cooled, the liquid contracts and descends in the tube. It is better to help children discover this for themselves than simply to tell them what will happen.

This demonstration thermometer is large and takes some time to warm up or cool off.

Fig. 2-37
It is easy to make a working model of a thermometer.



*Bring a simple thermometer in the class. Have children compare this with the working model thermometer described above. What are the similarities? What are the differences?*

### 4(b). TEMPERATURE IS EXPRESSED IN DEGREES

Children and adults use the temperature scale and the 'degrees' into which it is divided long before they know what the scale means. What many people do not realize is that the temperature scale and the degrees are purely arbitrary. A good way to get this idea across children's mind is to let them make their own scale, as in the activities suggested here.

**Investigation**

**How is a temperature scale prepared?**

*Materials required*
demonstration thermometer (from previous investigation),
cardboard for scale

Use the demonstration thermometer described in the previous activity. Fasten a strip of cardboard to the tubing; a scale will be made on this strip, as in Fig. 2-38. Place the thermometer in the coolest part of the room. Mark the liquid level on the scale after the thermometer has had enough time to cool off. Label this mark on the scale 'cool'. Now place the thermometer in the warmest part of the room or outside in direct sunshine. Allow it enough time to warm up. Mark this new liquid level on the scale and label it 'warm'. The space between the 'cool' mark and the 'warm' mark can now be divided into any convenient number of divisions. There might be four or eight or ten such divisions or 'degrees'. Help students realize that this is *their* scale, and it applies to *their* thermometer only. It is in every sense an arbitrary scale.

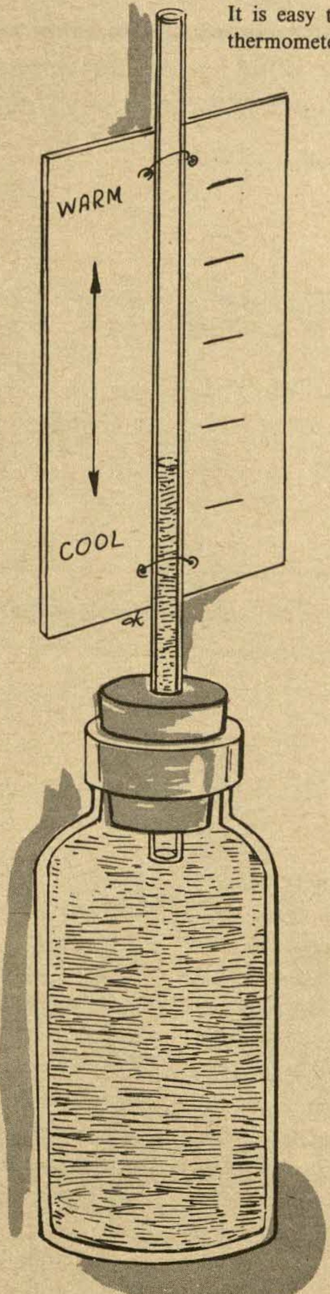


Fig. 2-38
It is easy to make a simple scale for a model thermometer.

**Investigation**

## Can we prepare a good thermometer scale?

*Materials required*
thermometer without scale, ice, cardboard or stiff paper

Remove an inexpensive thermometer from its scale. Fasten a strip of cardboard to the tubing; a new scale will be made on this strip as in Fig. 2-39. Mark on the strip the liquid level when the bulb of the thermometer is in crushed ice. Next, mark the liquid level when the thermometer is held under a child's tongue for one minute. The 'ice-mark' and the 'tongue-mark' are now the 'fixed points' of a thermometer scale. The distance between them can be subdivided into any convenient number of 'degrees'. Be sure to observe hygienic procedures in placing the thermometer in a child's mouth. Clean the thermometer by rinsing in alcohol, or by washing thoroughly in strong, soapy water.

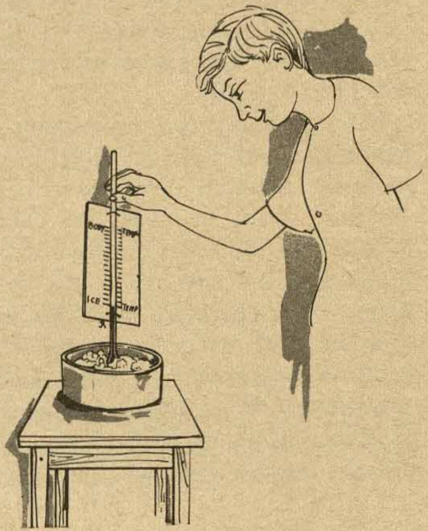


Fig. 2-39
A good thermometer scale requires two dependable 'fixed points'.

**Scientists at Work**

## Fahrenheit developed the first good thermometer

Gabriel Fahrenheit was a German scientist who was working and studying in the early part of the 18th century. Among other things, he was a skilled craftsman, and a maker of fine scientific instruments. At that time there were no dependable thermometers. Temperatures were simply compared with each other, and the accuracy of temperature estimation was poor indeed.

While reading scientific literature, Fahrenheit came across an article in which a simple thermometer was described. The author also indicated that he had used this thermometer to show that water always boils at the same temperature. (Today it is known that this is *not* true, the boiling point varies with air pressure.)

Skilled worker and curious scientist

as he was, Fahrenheit had a strong desire to make such a thermometer for himself. He encountered many problems, and found ways to improve on the primitive design. Finally, three years later, he had a thermometer which satisfied him. It operated dependably, but it had no scale.

Fahrenheit used two 'fixed points of temperature' to make his scale, much as in the previous investigation. For his cold point he took the lowest temperature he could get with a mixture of ice and salt. He called this 'zero degree of temperature'. For his hot point he took the temperature of a healthy human body, which he thought was constant. He called this '96 degrees of temperature'. He then divided the distance between these two fixed points of the thermometer into 96 equal intervals. In this way a temperature scale was developed—one which is naturally called the 'Fahrenheit scale'.

Since Fahrenheit's time, improved measurements have been made. For example, on the modern Fahrenheit scale, the temperature of a healthy human mouth is 98.6°F. Scientists in most parts of the world no longer use the Fahrenheit scale of temperature. Instead they use the centigrade scale. On this scale, pure water under standard pressure conditions freezes at 0°C, and boils at 100°C. The most modern scientists refer to this not as the 'centigrade scale', but as the 'Celsius scale', after Anders Celsius, the Swedish scientist who first proposed it.

*Help children compare the Fahrenheit temperature scale with the centigrade (Celsius) temperature scale. One Celsius degree is* 1.8 *times as great a temperature interval as is one Fahrenheit degree. The centigrade (Celsius) scale is officially adopted for all temperature measurements in India. See Fig.* 2-40.

**For Better Understanding**

Commercial liquid thermometers differ from the demonstration thermometer of Fig. 2-37 in certain important ways. Commercial thermometers are usually smaller, and they

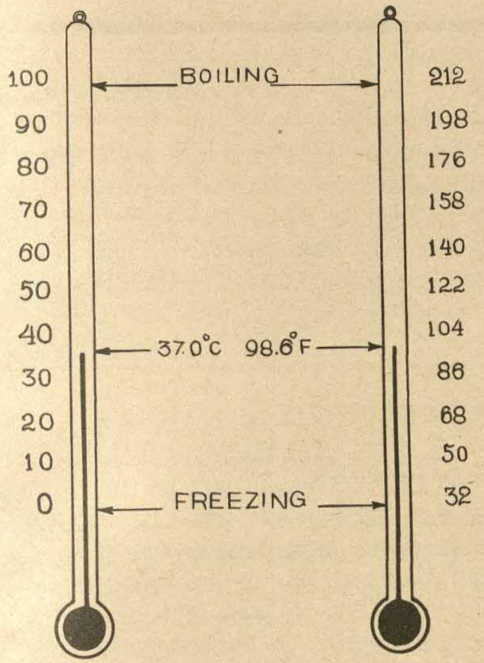


Fig. 2-40
The two scales show that 180 Fahrenheit divisions equal 100 Celsius divisions. Therefore, 1.8 Fahrenheit divisions correspond to one Celsius division.

contain mercury or coloured alcohol instead of water. Furthermore, a commercial thermometer is sealed at the top, and air is removed from the space within the tube.

If a thermometer is heated beyond the point where the liquid reaches the top of the tubing, the bulb at the bottom of the thermometer will break.

Some thermometers are made by having thin layers of two different metals secured together and shaped into a spiral. The two layers expand and contract differently with changes in temperature, thus making the spiral become looser or tighter. This movement makes a pointer move across a scale. In general, a thermometer which has a needle which moves across a scale is of this kind. It is called a 'compound bar thermometer', or a 'bi-metallic thermometer'.

## 5. WEATHER INFLUENCES TRAVEL, WORK, PLAY AND CLOTHING

Weather and its changing patterns influence boys and girls and men and women in many ways. These influences are not, strictly speaking, matters of scientific principle. Even so, they do illustrate the effects of weather on people and how the knowledge of a natural phenomenon helps one to understand and appreciate its effect upon him.

Among the many ways in which weather affects people, three are considered here. The sub-concepts listed below fall under three logical headings: safety, comfort and pleasure.

**5(a).** TRAVEL IS RISKY IN STORMY AND FOGGY WEATHER

When the weather is bad, travel becomes more dangerous. This is true whether travel be by land, by sea or by air. Here is a suggestion for a class discussion which will help students become aware of these dangers.

**Discussion**

**What kind of weather is good for travel?**

Ask children when (what time of the day or of the year and in what kind of weather) they and their parents prefer to travel. Try to focus their attention on the safety aspects of weather conditions. Help draw out from their discussion such travel hazards as slippery roads, strong winds, poor visibility, high waves, hail, washed out roads, and dangerous heat or dangerous cold. Help students see how each of these hazards applies to various forms of travel on land, also travel by sea and by air.

*Display pictures or tell stories of foul-weather situations which can cause serious accidents.*

**5(b).** OUTDOOR WORK IS HARD AND OPEN AIR GAMES ARE UNCOMFORTABLE DURING BAD WEATHER

One result of 'bad weather' is that it causes discomfort to those who work or play in such weather. While being out in such weather may not be actually dangerous, it is definitely uncomfortable. Well-guided discussions can help children appreciate this kind of effect which weather has on the activities of people.

**Discussion**

**What kinds of weather are most uncomfortable?**

Ask children to tell from their own experiences what kinds of weather are most uncomfortable for work or play. They may be expected to suggest such things as very hot, very humid or very cold days, rainy and stormy days, days when the sun is too bright or when the wind blows sand and dust into their eyes. Help them realize that such weather conditions make work or play uncomfortable and that this is one of the ways in which the weather affects their daily activities.

*Invite children to make simple sketches of different kinds of weather they like, and of those they don't like.*

### 5(c). GOOD WEATHER IS A PLEASANT TIME FOR TRAVEL AND FOR SPORT OR PICNICS

Sometimes weather conditions are not bad enough to make work or play dangerous, or even uncomfortable. Instead, they merely make outdoor activities unpleasant. On the other hand, good weather definitely makes such activities very desirable; a person feels like working and playing. When the weather is very fine, it helps a person feel 'glad to be alive'—and willing to engage in all his activities whole heartedly. Children can be helped to realize this through guided discussion such as one described below.

**Discussion**

**What kinds of weather are most pleasant?**

Ask children to tell what time of the day or of the year they find the weather most pleasant of all. They may give answers such as 'very early morning', or 'the cool of the evening', or 'November through March', or 'just after a good rain'. Encourage them to say what it is about their favourite weather which they like so much. Answers can be expected in terms of 'pleasant temperature', 'clean air', 'invigorating atmosphere', or 'fun to be outside'. Help children realize that really good weather is not simply the absence of bad weather, but that good weather has definite desirable features of its own.

*Invite children to suggest a day for a picnic, or a pleasant walk together. Help them realize that the weather influences their choice of such a day.*

**For Better Understanding**

One of the chief goals of this major concept about good and bad weather is to make students think about weather and its effects on the activities of people. Because man is so influenced by weather, he seeks to do something about it. Accordingly, he tries to understand what causes weather and its changes, and how weather can be reliably predicted. Man also controls 'weather conditions' inside his buildings by constructing them in such a manner as to take advantage of favourable shade or breeze, or by simply building structures which keep out the rain and wind! More and more, man controls the 'inside weather' with heaters and coolers, artificial light and artificial breeze (electric fans). Throughout the world, man is gradually learning a little about actually controlling the weather. Much of the modern meteorological research is aimed at better understanding of the weather, so that prediction and control of it can be more effectively carried on.

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# UNIT 2

# AIR, WATER AND WEATHER

## CLASS IV

### Overview

Man's surroundings of air, water and weather are not merely things which he is obliged to accept. Rather, they are essential materials without which he cannot exist. Air is used by living things—both plants and animals. Air also takes part in all ordinary kinds of burning, as well as in the rusting of iron and steel and in the chemical changes which many rocks slowly undergo. Water is an essential part of the food and drink of animals, and provides raw materials for the photosynthesis of food materials by plants. It is used by man for washing himself and his possessions, for keeping cool, for dissolving many everyday substances. Water is also used as a means of transportation, and for many industrial purposes. The changing pattern of weather is largely concerned with air and the water it contains. So, it is natural that air, water and weather are grouped together in this unit of the Syllabus.

At earlier class levels, students have learned about air, its properties and behaviour. They have also learned much about different kinds of weather and something of their physical causes. At this class level, they will have a chance to learn more about the physical processes involved in weather. These processes include the effects of solar heating, the upward movement of warmed air, the ability of air to contain water vapour, and the manner in which water vapour precipitates (changes from a vapour) from air. They will also have a chance to learn how man makes impure water clean enough to use, and how water is stored in and removed from the earth.

The teacher's emphasis in this unit should be on major concepts 2, 3 and 4. These are concerned with fundamental physical relationships between air, water and temperature. If these major concepts are well understood, students will have an easier time with the other, more descriptive, and advanced concepts in future class levels.

### 1. THE SUN PLAYS AN IMPORTANT PART IN CAUSING CHANGES IN WEATHER

Adults usually realize the general relationship between the sun and the weather. Children, however, often fail to see the cause-and-effect relationship between the two.

Sometimes they suggest that the sun is shining because it is warm or because it is daylight. Even adults are sometimes unaware of the relationship between the sun and clouds or between the sun and winds.

In this and the following major concepts, children will begin to see how energy from the sun affects weather in many ways. Here the foundation is laid for the broad generalization that the earth is really a giant thermal engine, converting solar energy into all aspects of weather, as well as into other energy forms.

**1(a).** THE SUN WARMS THE EARTH DURING THE DAY

The sun warms up objects on which it shines. Even on a cold day, the radiation from the sun is pleasantly warm. Many children know this from their own personal experience. For other children, an activity such as this will provide evidence from which the heat-giving effect of the sun can be developed:

**Investigation** **How does sunshine affect temperature?**

During the morning, while it is still cool, ask children to find the warmest spot they can but not one warmed by fire or other artificial source of heat. Let them look for it both indoors and outdoors. Different children may select different spots. In general, however, they will be spots that are in the sunshine—often those that have been in the sunshine for an hour or so. Ask children to explain what has made their chosen warm spot as warm as it is. Ask them also to find cool spots, and explain why they are cool. Help them develop the idea that it is the warmth of sunshine which makes these areas warm.

*Help children observe that, while they stand in the sun, the sides of their bodies exposed to the sun are warmer than the sides away from the sun.*

*Use a small magnifying glass to concentrate sun's heat. Be careful of the possibility of starting a fire.*

**For Better Understanding**

Actually, equal intensities of sunshine warm some things more than others. An important factor here is the colour of the object. In general, dark and rough objects are warmed more by sunshine than are light-coloured or shiny objects. A special case is a mirror, which is warmed scarcely at all even while in strong sunlight. Similarly, the sun shining through a window on a cool day warms the inside of the room, but does not warm the glass itself very much. Simple experiments can easily be designed to help interested students arrive at these conclusions.

### **1(b).** THE SUN WARMS THE EARTH MORE IN SUMMER THAN IN WINTER BECAUSE THERE ARE MORE HOURS OF SUNSHINE IN SUMMER THAN IN WINTER

One of the reasons that summer is warmer than winter is because the summer days have more hours of sunshine than do winter days. It would not be enough just telling the students about it. They can be helped to draw on their own experience to find this out. Here are some activities from which supporting evidence can be gathered.

**Investigation**

**Why are summer days longer than winter days?**

*Materials required*
large ball or round earthen jug, source of bright light, clay, short straight stick

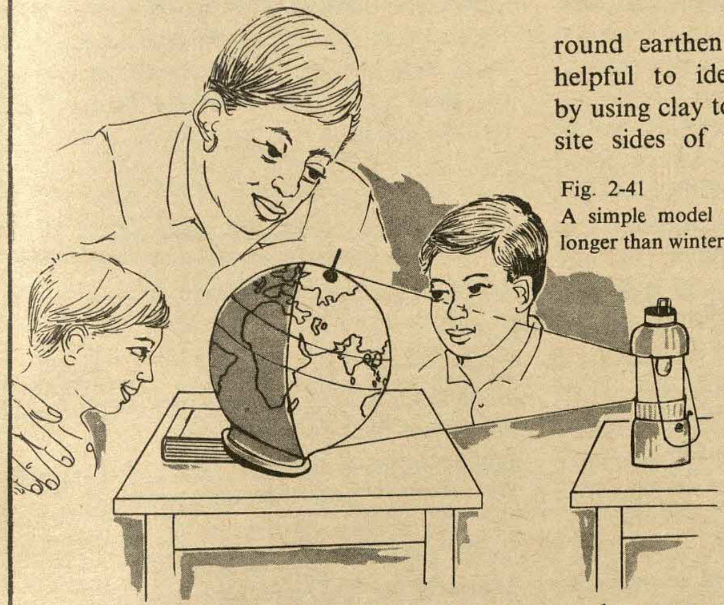


Fig. 2-41
A simple model shows why summer days are longer than winter days.

Use a model of the earth to study the effects of the sun in producing day and night, as in Fig. 2-41. If no earth-globe is available, use any large round ball, the bigger the better. A large round earthen jug is excellent. It is helpful to identify the earth's axis by using clay to mount sticks to opposite sides of the ball. This activity works very well when carried out in the sunshine, but best when the sun is quite low in the sky. Or the source of light may be a bright lamp—or even an electric torch.

In carrying out this activity, the earth's axis can remain vertical at the beginning. If children object and say the axis should be tilted, this can be done too. However, during the first part of the activity, when emphasis is on earth's rotation and day and night, the tilt of the earth's axis is not necessary.

Shine the light on the ball and lead children to agree that one half of the earth is lit by the sun, while the other half is in the dark. Twist the globe on its axis and help children see how any one spot on the earth has alternate daylight and darkness. Challenge students to tell which way the earth-model should be rotated. They can figure this out by recalling that the sun seems to rise in the east, and seems to set in the west. (For a proper model, the earth should be rotated anti-clockwise as seen from the top). Draw a circle around the ball at the equator. Draw another at the latitude of the school. (Consult a map to find the latitude of the village or town.) Help children realize that the second circle represents the path of a person moving around the earth at the latitude of their locality.

Now tilt the 'north pole' of the earth-model towards the 'sun' as suggested in the sketch. Ask children to study the 'circle of constant latitude' to see whether it is mostly in the sun or mostly in the dark. (Unless the locality is very near the equator, the circle will obviously be more in the light than in the dark.) Help children realize that this means during the hours required for the earth's rotation, their locality is in the sunlight for a longer time than it is in the darkness. Repeat this with the north pole tilted away from the sun, and help children see that under this condition, their locality has days that are shorter than nights.

**Familiar Experience**

### How does the length of the day vary throughout the year?

Ask children to recall which days of the year are the longest. Most of them can easily recall that during the late spring and summer months the sun rises earlier and sets later than it does during the autumn or after the monsoon. Select a group which will record the time of sunrise and sunset. How does this compare at different times of the year? Consult the local newspaper to see when the sun rises and sets. If possible, consult newspapers from several months back to see how the time of sunrise varies at different times of the year. In particular, help students realize that the longest day is on or nearly on 21 June, and the shortest day on or nearly on 22 December. Also help them realize that when the days are long the nights are short and *vice versa*.

*In places far from the equator (at higher latitudes) the difference between summer-day length and winter-day length is more pronounced. Tell children stories about these unfamiliar and interesting conditions. See also "For Better Understanding" below.*

**For Better Understanding**

The earth travels around the sun in a nearly circular orbit. However, the axis of earth rotation is not perpendicular to the plane of this orbit, but is tilted 23-1/2° from the perpendicular. The axis always points in the same direction (towards Polaris, the North Star). As a result, the earth's axis is tipped in general towards the sun (during late spring and early summer) and away from the sun (during late autumn and early winter). This cycle of change repeats itself every revolution of the earth around the sun, and produces the annual cycle of the seasons.

In central India, summer days are 13-14 hours long, while summer nights are only 10-11 hours long. In winter, these figures are reversed. In the northernmost parts of the nation, a midsummer day approaches 15 hours in length. The year's longest day is on 21 June, but the days within a month of that date are nearly as long. The shortest day is on 22 December, but days within a month of that date are nearly as short. People living at the equator have days and nights each twelve hours long throughout the year. At the latitude of northern Europe and Russia, summer days are very long indeed. Beyond the Arctic Circle (66-1/2° north latitude) days in midsummer last the full 24 hours. This region is sometimes called 'the land of the midnight sun'. For many weeks during midwinter the sun does not rise at all at these far-northern latitudes.

**1(c).** THE SUN IS MORE DIRECTLY OVERHEAD IN SUMMER THAN IN WINTER; HENCE THE SUN'S RAYS ARE MORE INTENSE AND WARM THE EARTH MORE

Although the length of days and nights is an important factor in producing the cycle of the seasons, it is not the only one. The fact that the sun shines from more nearly overhead in summer also has an important effect. Here are some activities which can help children understand this important relationship:

**Investigation**

**Why is the sun higher in the sky in summer than in winter?**

*Materials required*
sphere (earth model),
source of bright
light

Use the ball and source of light for an earth-sun model as shown in Fig. 2-42. Ask children to imagine themselves living at a spot in the northern hemisphere, and to think how the sun would look to them at different times of the year. Help them realize that the sun appears to be more nearly overhead in

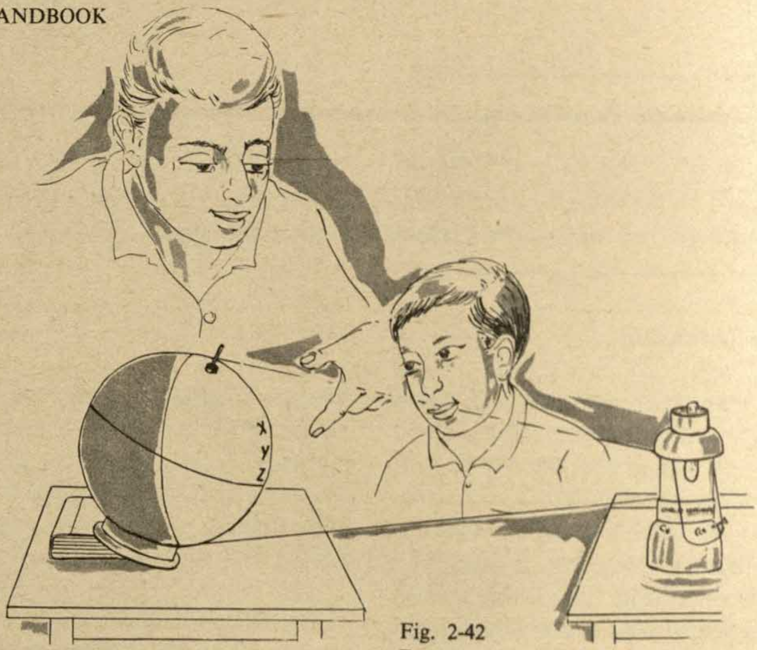


Fig. 2-42
From more northerly locations, the sun appears higher in the sky in summer.

the sky in summer than in winter. Ask them what difference this might make in the sun's heating effects. Then go on to the next investigation.

**Investigation**

### How does the angle of the sun's rays affect the heat provided?

*Materials required*
dark paper or cloth,
thermometer (if possible)

Arrange two places, indoors or outdoors, where the sun shines on similar surfaces, but at different angles. One good way is to hold two sheets of dark paper or cloth so that the sun strikes them at different angles. Or, as suggested in Fig. 2-43, there may be two outside walls which receive morning sunlight at different angles. The difference in

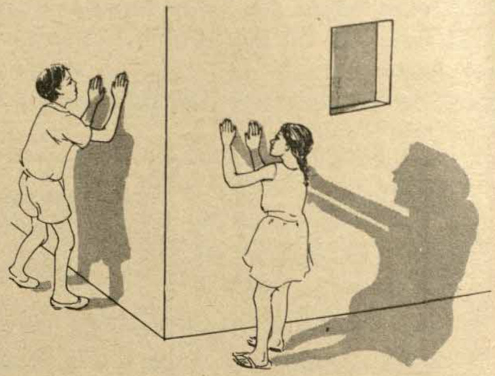


Fig. 2-43
Direct rays of the sun provide more heat than slanting rays.

temperature can be felt with the hands after a few minutes. If a thermometer is available, it can be used to measure the temperature difference more accurately. Try not to tell the students in advance what the results might be. Permit them to discover on the basis of their own first-hand evidence that sunlight shining more directly (from a more nearly perpendicular angle) on a surface, warms it more than when it strikes the surface at an angle.

*Compare the temperature of two sunlit walls of the school—one where the sun shines quite directly and the other where the sun's rays strike the surface at a slanting angle.*

**For Better Understanding**

Without understanding the reason, children and adults often cause surfaces to be turned towards a heat source to get them warmed. Thus children turn their hands and faces directly towards a fire for maximum heating. Other things being equal, the side of a hill which faces the sun has warmer soil than the side which does not face it directly.

**1(d).** DURING THE DAY, THE LAND GETS WARM SOONER THAN THE WATER AND THE AIR ABOVE THE LAND GETS WARM SOONER THAN THE AIR ABOVE THE WATER

Different materials are affected differently by the sun, not only because of their colour, but also for other reasons. Soil and water, the two most abundant materials on the earth's surface, are an interesting and important example. Soil gets warmed faster under the sun's radiation than does water. It is not enough simply to *tell* this to children. It is better to provide evidence such as the following so that they can form their own conclusion:

**Investigation**

**Which is more easily warmed—soil or water?**

*Materials required*
two glass jars, dry soil, water, thermometer (if possible)

Arrange two identical glass jars, one filled with water, the other with dry soil. Cover each of them. Allow them to stand overnight so that they come to the same temperature. If possible, check with a thermometre, and record the results. Now place the two samples under identical conditions of warm sunshine for an hour or so, as in Fig. 2-44. Do not stir the water. The difference in temperature can usually be felt with hands; better yet, it can be

Fig, 2-44
Soil is more easily warmed by sunshine than is water.

measured with a thermometer. Help children realize that not only does soil warm up sooner in the sunshine than does water, but even the air above the land is warmed by the land, and therefore warms up sooner than the air above the water.

*Permit children to compare the temperature of pond water and nearby soil on a sunny day. Or they can compare the temperature of a deep pan of water which has been exposed to the sun several hours with that of the nearby soil.*

**1(e).** AT NIGHT, LAND COOLS FASTER THAN WATER AND THE AIR ABOVE LAND COOLS FASTER THAN THAT ABOVE WATER

Just as there are differences in the way soil and water are warmed by sunshine during the day, so is there a difference in the way these two materials cool off at night. An activity much like that suggested above can be used to help students acquire this information.

**Investigation**

**Which is more easily cooled—soil or water?**

*Materials required*
two glass jars, dry soil, water, thermometer (if possible)

Arrange two identical glass jars, one filled with water, the other with reasonably dry soil. Cover both jars. Arrange to have them heated to the same temperature, possibly with the aid of a fire. If possible, check these temperatures with a thermometer and record the results. Now permit the two samples to cool in the shade in the afternoon or evening. Do not stir the water. Measure the temperature of the two samples after an hour or so. Help children form the conclusion that, other things being equal, soil cools off more rapidly than does water.

*Help children recall that water feels warm when they swim on a cool evening. Actually, the water has remained warm longer than the nearby soil.*

### For Better Understanding

The difference in the rate of warming of soil and water is closely related to the difference in their rates of cooling. Part of the reason for this difference is simply the nature of the material. Many more units of heat energy are required to warm a one-litre jar full of water to a given temperature than are required to warm a one-litre jar full of soil to the same temperature. There are other reasons also for this difference.

For one thing, water is transparent, and heat radiation, like light radiation, penetrates somewhat below the surface. As a result, the heating effect of sunlight on water is distributed to a moderate depth, while the heating effect of sunlight affects only the surface of the soil.

For another thing, water is a fluid. As a result, convection currents can be set up which mix layers of water of different temperatures. This is particularly true when water cools off in the evening. As soon as the top layer cools, it becomes slightly more dense and sinks. Its place is then taken by slightly warmer water from below. As a result, water tends to cool to a considerable depth, while cooling of the soil occurs almost completely at the surface.

The differences in heating up and cooling off between soil and water are of great importance in producing local and also large-scale weather. In the long run, the resulting temperature differences have a great deal to do with local breezes, and also with the seasonal pattern of the monsoons. This material is taken up in the next major concept. Children should be helped to see the relationship between this major concept (1) and the one which follows (2).

## 2. HOT AIR IS LIGHTER THAN COLD AIR

In referring to the weight of air, one usually thinks of the weight of a certain volume of air, such as a cubic metre. Thus, a cubic metre of warm air weighs less than the same volume of cold air. Sometimes children think that when a certain quantity of air—say, a bottleful is heated, it somehow loses weight. Students must be helped to realize that warm air is lighter than the same volume of cold air because when the air is heated it expands or becomes larger. This physical action is responsible for many of the things that happen in the weather from day to day. The sub-concepts which follow are intended to help children understand the physical changes which happen when air is heated, and their effects on the weather.

### 2(a). WHEN AIR IS HEATED IT EXPANDS

Adults know that when air is heated its molecules are in more violent motion, and hence are farther apart. As a result, a given volume—such as a cubic metre—of heated air contains fewer molecules than the same volume of air before it was heated. Each molecule weighs the same as it did before being heated; but after expansion, there are fewer molecules in a given volume of the air. This is a difficult but important point to understand. Activities such as those which follow can help make them understandable to students at this class level.

**Investigation**

**How does heating a gas make it lighter?**

*Materials required*
soft drink bottle,
balloon,
source of heat

Place a balloon over the mouth of a soft-drink bottle which is perfectly dry and clean. The balloon should be pre-stretched to make it easy to inflate. Now heat the bottle gently in a flame. Be very careful that the bottle is not broken by sudden and uneven heating. Challenge students to notice what happens to the balloon. Gradually, it becomes partially filled with air, as in Fig. 2-45. Help students to understand what has actually happened. Help them see that the same total quantity of matter (the same number of molecules) which formerly occupied *only the bottle* now occupies the bottle *and also the balloon.* As a result, there is less matter (fewer molecules) in the bottle. If there were a convenient way to weigh it, it would be expected that the warm air *in the bottle* since it contain fewer molecules, weighs less than the cooler air in the bottle, with the additional number of molecules.

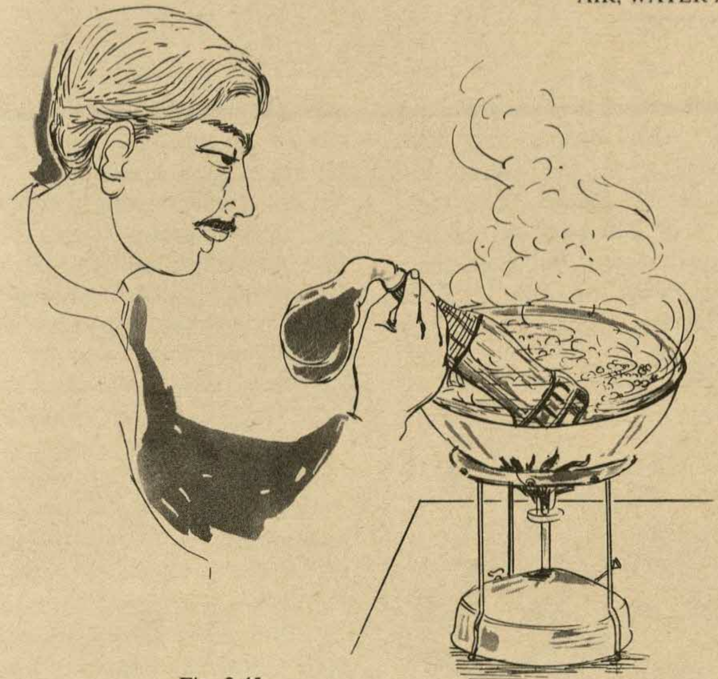


Fig. 2-45
When a container of air is heated, part of the air is driven out of the container.

**Investigation**

**Why does air expand when it is heated?**

On the floor or on the ground draw a circle or a square a metre or so across. Ask several students to crowd into this area—perhaps eight or ten can stand there comfortably if they stand still, as in Fig. 2-46a. Now ask this group of students to jump up and down. Perhaps only five or six can now occupy the same space, as in Fig. 2-46b. Assume that eight students

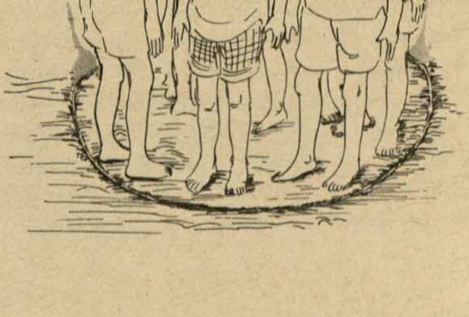


Fig. 2-46a
When children stand still, they require less space.

are in the circle while they are exercising vigorously. Also assume that each student weighs on the average 30 kilograms. At the out-set, then, there were 8 × 30 or 240 kilos of children in the assigned space. But later, there were only 5 × 30 or 150 kilos of children in the same space. Just as in the case of molecules, each child weighs as much as he did before. However, in a given space, a group (five) of rapidly moving children weighs less than a group (eight) of nearly motionless children. Help the children to see the analogy between moving children and moving molecules.

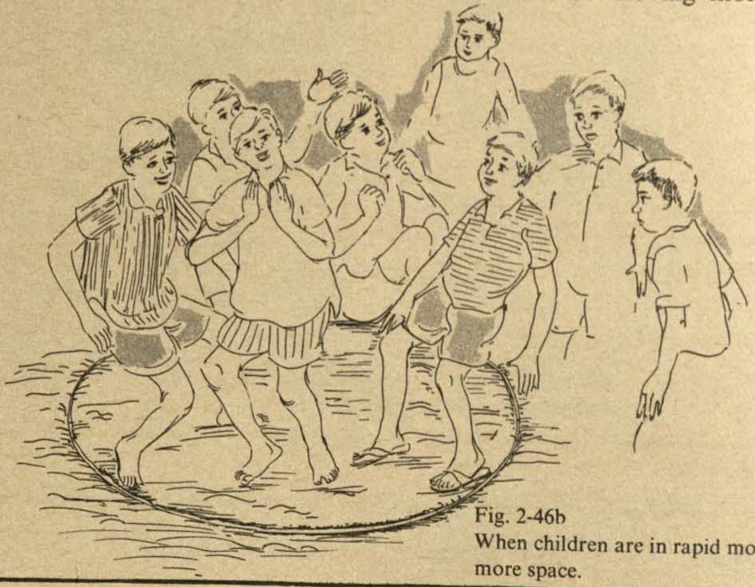


Fig. 2-46b
When children are in rapid motion, they require more space.

*Show pictures or tell stories about air balloons—huge bags of heated air which carried men up in the first lighter-than-air craft, nearly two hundred years ago. See also "Scientists at Work" on page* 190.

## 2(b). COLD AIR PUSHES THE WARM AIR UP

When two bodies of gas are side by side and are free to move, the lighter one (weighs less for the same volume) will go up while the heavier one (weighs more for the same volume) will go down. Actually, the light air does have weight, and it is not violating the law of gravity. Rather, the heavy air is pulled down more by gravity, and forces the lighter air to rise. This is a little like a heavy child on one end of a seesaw forcing the lighter child on the other end upwards. In the case of air, this action is difficult to see because air is usually invisible. Here, however, are activities which can help children grasp this important principle.

**Investigation**

### How do heavy fluids force lighter fluids to rise?

***Materials required***
inexpensive oil,
water, glass jar

Oil is lighter than water. In this investigation, let any inexpensive oil serve as the model for warm (light) air, while water serves as the model for cool (heavy) air. Place oil to a depth of a few centimetres in the bottom of a clean, dry glass tumbler or bottle. Help students realize that this corresponds to light in this experiment. Now carefully pour in water, as in Fig. 2-47. Challenge students to observe what happens to the oil, and to explain why it behaves in this way. Help them realize that the water corresponds to heavy air. In particular, help them see that the oil, which does have weight, is forced upwards by the water which is even heavier. Help them think of warm (light) air being forced upwards in a similar way by cool (heavy) air.

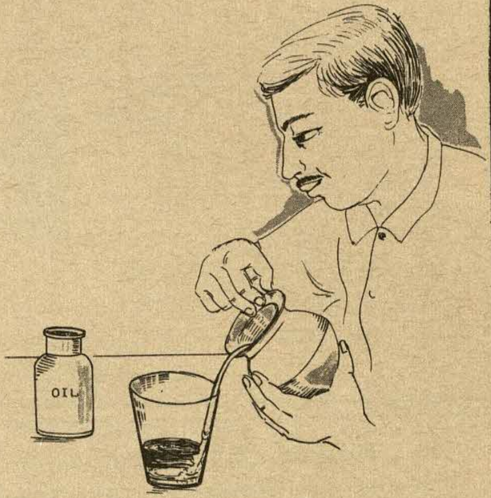


Fig. 2-47
It is easy to see how a heavy fluid forces a lighter fluid to rise.

**Investigation**

### Why does smoke rise?

***Materials required***
lamp, match

Light a candle or a kerosene lamp and observe it in a part of the room where there are no stray air currents. The movement of the air can be made visible by putting some chalk dust or other fine dust in the air, or with the smoke from incense, as in Fig. 2-48. Ask children to observe what happens to the air which is warmed just in and above the flame itself. Help them understand that this warm air expands, becomes lighter (for a given volume of the air) and is then forced upwards by the cooler air which surrounds the flame.

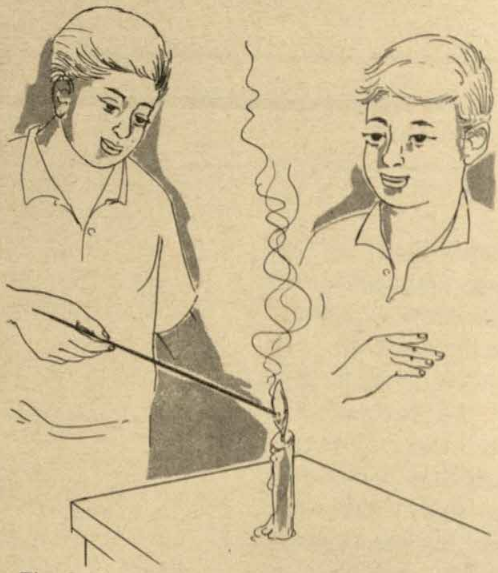


Fig. 2-48
Smoke rises because it is carried up by warm air.

*Remind children that it is hottest above the fire in the chula. Also help them recall how smoke rises from fire, whether there are chimneys or not.*

**Scientists at Work**

**The first balloons rose because they were filled with hot air**

As far back as we know, man has wanted to fly. Early legends and epics refer to the flight of men. Indian mythology contains many examples of flight, such as that of Hanuman, who flew to Lanka with herbs to save the life of Rama's brother—Laxman. Western literature also contains many references to the desire of men to fly, and to the flights of the gods of mythology. Almost without exceptions, these flights or attempts at flight were made with artificial wings, or other similar attempts to imitate the flight of birds.

In about 1250, Roger Bacon, an English scholar, proposed a balloon which would rise because it was filled with a light-weight gas, but he made no successful attempt to launch such a balloon. In 1505, Leonardo da Vinci, famous Italian painter, sculptor and scientist wrote a complete book about ideas for human flight. This included some of the ideas that are even now used in the flight of helicopters.

In the seventeenth century, scientists again turned their attention to the idea of Bacon, of having a lighter-than-air craft. But what were they to do for a light-weight gas? Some suggested using metal balls from which the air was expelled (vacuum-filled spheres). Others proposed using air from high altitude, where it was known that the atmosphere was more rarified, and hence lighter for a given volume. But it was two brothers, named Montgolfier, of France, who used a slightly different approach and launched the first successful balloon in 1783. They carefully studied the behaviour of chimney smoke. Then they constructed a round silk bag and planned to fill it with the same material which made chimney smoke rise, that is, hot air. The hot air was supplied by a bundle of burning paper, straw, and sticks. After more and more successful trials, they finally made a balloon some nine metres in diameter. On its very first flight it went nearly two kilometres high, and came to earth some two and a half kilometres away! Later in the same year, they made a still larger hot air balloon which carried a sheep, a duck and a rooster to a distance of a mile and a half in eight minutes. These were the first passengers in the history of aviation.

Hydrogen, a very light gas, was discovered only a few years before the Montgolfier brothers' first balloon was launched. Soon after, scientists began to direct their attention towards hydrogen-filled balloons. Hydrogen, although an excellent lifting agent, is extremely explosive and hence dangerous. Today nearly all lighter-than-air craft are filled with helium—a more expensive but much safer gas than hydrogen.

The fact remains, however, that the first successful flights in the history of man were made using nothing but hot air as a lifting agent. Even this brief study of the development of early flight shows that the process has been very slow, requiring a great deal of careful investigation and the work of many scientists from many different nations.

## 2(c). REPLACEMENT OF WARM AIR WITH COOL AIR CAUSES WIND

In the case of the candle or the kerosene lamp (see Fig. 2-48) the warm air is forced upwards by the cooler air which is outside the flame. In nature, however, the cool air often has to come from many miles—even hundreds of miles. For example, when warm air over a desert is heated, the cool air may come from a long distance. As it moves over the hot desert, it too becomes warm. This kind of action is also responsible for a 'loo' wind in the summer. The activity below can help students understand how this action occurs.

**Investigation**

## How can a convection box help in a study of warm air?

*Materials required*
cardboard box,
lamp chimney,
cellophane,
candle, match,
source of smoke

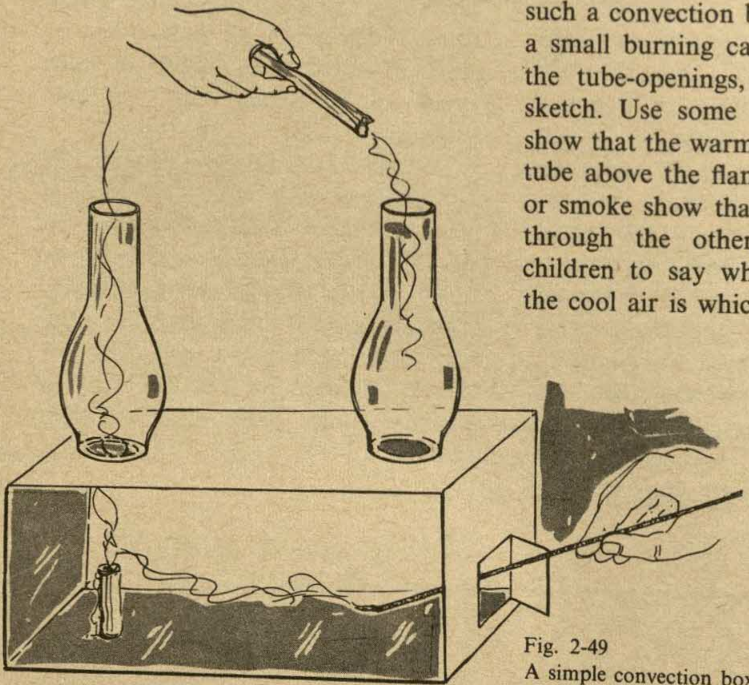


Fig. 2-49
A simple convection box provides an ideal way to study air currents.

Construct a simple 'convection box' as suggested in Fig. 2-49. The two tubes can be glass lamp chimneys, or they may be simple paper tubes. The front of the box is covered with glass or with transparent plastic. Small holes in the ends of the box permit handling of materials while the box is in operation. These small holes could have doors or other means of closing them. This kind of convection box can be easily made with materials readily available about the school. In many cases, children, perhaps with the aid of an older person, can make and use, such a convection box at home. Place a small burning candle under one of the tube-openings, as shown in the sketch. Use some kind of smoke to show that the warm air is rising in the tube above the flame. Also with dust or smoke show that air is descending through the other tube. Challenge children to say where the source of the cool air is which forces the warm air to rise. What is the path of the cool air as it moves towards the flame? If the floor of the box is a hot desert, what will happen to this cool air as it moves along? Help children see the relationship between this model and the formation of a 'loo' wind.

*Tell children stories about 'loo winds'. Have them ask their parents about experience they may have had during such winds.*

**2(d).** THE MORE THE DIFFERENCE IN TEMPERATURE BETWEEN THE COLD AIR AND THE WARM AIR, THE STRONGER IS THE WIND

If the cause for any action is increased, the action itself is usually increased. This is the case also when the cool air forces the warm air to rise. The greater the difference in temperature between the cool air and the warm air, the stronger will be the resulting air movement. Here is a 'memory activity' which can help children find evidence to support this principle.

**Familiar Experience**

**Do large temperature differences produce strong winds?**

Ask children to think carefully about the degree of motion involved when air moves upwards over a candle flame or the flame in a kerosene lamp. Now ask them to think of the biggest fire they have ever seen. What was the nature of the air movements in relation to this fire? Were the upward currents of the large fire strong enough to lift large pieces of paper, or other large pieces of burning material? Help the children see that a more violent action is produced by greater differences in temperature between the warm air and the cool air which forces it upward.

*Contrast the behaviour of smoke—or of a paper pinwheel—above a small candle flame and that above the much larger flame of a kerosene pressure-burner.*

**For Better Understanding**

Scientists call the air (or water) currents which are produced by temperature differences 'convection currents'. Although convection currents are usually thought of as vertical movements of the air, they also produce large and important horizontal air movements or winds. Thus, air rises over the warm land on a summer afternoon. It is forced up by the cooler air which is over the nearby water. The result is a cool breeze from the ocean or from the lake.

In the summer, as the land mass of Southeast Asia gets hot, the air above it expands and becomes lighter. It is then forced upwards by the relatively cool wind from the oceans to the south. These water-laden winds from the ocean bring rains. In the winter reverse is the case. The warm air over the water is forced upwards by the relatively cool air from the continent. This produces winter winds which are dry and blow in general from the land to the sea. These are the winter or 'dry monsoons'. On an even larger scale, the warm air in the region of the equator rises, because the cooler air from nearer the poles comes in to push it upwards. This action, complicated a great deal by the rotation of the earth, is the principal cause of the world-wide pattern of winds.

## 3. CHANGE OF WATER INTO VAPOUR IS CALLED EVAPORATION

The ideas of this major concept are a direct follow-up of those in this unit, class III, major concept 1. From experiences in that section, children already know that water, like many other common materials, can exist in any one of the three physical states, that is, solid, liquid, or gas. They also know that if energy is provided, water changes from a solid to a liquid (melts), or from a liquid to a vapour or gas (evaporates or boils). When energy (heat) is removed from steam or water vapour, it returns to the liquid state (condenses). When heat energy is removed from liquid water, it changes to solid ice (freezes). It is well to review these relationships with children before undertaking the activities on this major concept.

This section is concerned only with one change of physical state, from liquid water to water vapour. This may be evaporation, a slow change at an ordinary temperature; or it may be boiling, a more rapid change taking place at a higher temperature, the boiling point. The sub-concepts are related to various aspects of this evaporation process.

### 3(a). WHEN WATER EVAPORATES, IT GOES INTO THE AIR

The process of evaporation is one in which molecules of liquid water escape into the air. When in the air, they are among molecules of nitrogen, oxygen, argon, carbon dioxide, and other gases which are there. The water molecules are not visible. They are far, far smaller than the tiniest particles of dust or pollen which may also be present in the air. Strictly speaking, water molecules in the air at ordinary temperatures make up *water vapour*. However, it is also common to refer to this material as a *gas*. Energy is required for the process of evaporation to occur. This means that each molecule which evaporates takes energy (heat) with it, leaving the remaining water cooler. It is for this reason that when water evaporates, it cools the objects from which it evaporates.

In previous classes there have been several activities which help children realize that evaporation transfers water into the air. Here in class IV, it is not necessary to repeat the activities. However, it is useful to review the understandings which arise from the activities.

### 3(b). THE RATE OF EVAPORATION IS AFFECTED BY SEVERAL FACTORS

Under some conditions, water evaporates very rapidly; under others, it may evaporate slowly or not at all. In general, the conditions which make for rapid evaporation may be thought of in terms of 'energy available for the evaporation process' and 'opportunity for molecules to escape from the water surface into the air'. The second item below (ii) relates to 'energy available'. The other three (i, iii and iv) relate to 'opportunity'.

*(i) Water Evaporates faster when it is windy*

The rate of evaporation is increased when it is windy, and this is for a very obvious reason. Air is well circulated above the surface of the water. As some molecules evaporate into the air, other (usually drier) air comes along to take its place. It is easy to have students make observations which will support this.

**Investigation**

**How does wind affect evaporation?**

***Materials required***
two identical pans,
water

Help the students arrange two identical pans of water. The pans must be of the same size and at the same temperature. Place one in a place where there is no wind, and the other where there is a steady breeze. Observe which evaporates more rapidly.

**Investigation**

**How does air movement affect evaporation?**

***Materials required***
water

Moisten the back of a student's hand with water. Ask him to note the feeling when he blows on it, and when he does not blow. It feels cooler when he blows air across the moisture. The coolness which results from evaporation is an indication that evaporation is taking place rapidly.

*Recall with students how clothes dry better on a windy day.*

*Discuss with students how they are cooled by a breeze when they are wet from perspiration, or from swimming.*

*(ii) Water Evaporates faster when the Temperature is high*

Energy (heat) is needed for evaporation. So it is natural that water evaporates more rapidly when there is an ample supply of energy. High temperature means high molecular energy, so high temperature produces rapid evaporation. Simple experiments can provide students with first-hand evidence from which this relationship can be developed.

**Investigation**

**How does temperature affect evaporation?**

*Materials required*
two identical pans,
water,
**source of heat**

Arrange two identical pans. They should have equal amounts of water. They should be side-by-side, except that one is heated with a candle or other simple source of heat. Have students measure the time required for each to evaporate to dryness. Point out that the only difference is temperature, and help them see the relationship between high temperature and rapid evaporation.

*Recall with children how quickly water evaporates from a hot road, as compared to the speed of evaporation from a cool road.*

*Remind children how a hot pan which is wet will dry very quickly, while a cold wet pan must often be wiped to dryness.*

*(iii) Water Evaporates faster when the exposed Surface is large*

When water evaporates, the molecules must get through the water surface into the air. Obviously, then, the larger the surface, the more opportunity molecules have to escape the liquid. Simple experiences can provide first-hand evidence on which students can develop this understanding for themselves.

**Investigation**

**How does surface area influence evaporation?**

*Materials required*
bottle,
**shallow pan**

Arrange two equal quantities of water at the same temperature. Place one in a bottle and the other in a shallow pan. Allow them to evaporate under otherwise identical conditions. Have students measure the time required for each to evaporate to dryness. The shallow pan may evaporate in an hour or so, while the bottle may not completely evaporate for many days. Ask students to explain the difference in the rate of evaporation.

*Attempt to dry out two identical pieces of moist cloth—one stretched out, and the other folded into a tight bundle. Point out to children the difference in the exposed area of the two pieces as they dry.*

*(iv) Water Evaporates faster when the Air is dry*

Water molecules cannot enter the air in unlimited numbers. When some water vapour is already present, more molecules enter the air with increased difficulty. At some point, depending on temperature and pressure, the air becomes saturated with water vapour. Then no more molecules can enter. The relationship between the dryness of the air and the rate of evaporation can be brought out through activities such as these.

**Familiar Experience**

**How does dryness of air affect evaporation?**

Ask students to recall under what conditions perspiration seems to evaporate most rapidly, and when clothes dry very slowly or not at all. Usually, they will respond that clothes dry slowly when the monsoons approach, or when it is raining. Perhaps they will say this is the case when the air is very moist or humid. Help them realize that the presence of some water molecules in the air makes it more difficult for new ones to leave the water and enter the air. This might be discussed in terms of getting a job. The more people already there are in the Administrative Service, the more difficult it is for other applicants to get jobs, other things being equal. Also, the more students already there are in a classroom, the more difficult it is for additional students to be admitted.

*Discuss with children how on a warm day they often feel cooler outdoors (where it may be relatively dry) than in a school room (where the humidity may be quite high). The difference in comfort is due, in part, at least, to more rapid evaporation of perspiration outdoors where the air is dry.*

**For Better Understanding**

Evaporation is a rather complicated process. While students need not go into the details, it is useful for the teacher to know some of them. The reverse of evaporation is *condensation.* This process also takes place most of the time. When water evaporates, it really means that there are more molecules leaving the liquid and going into the air than there are molecules which leave the air and condense into the liquid. When the air is saturated, the rate of evaporation and the rate of condensation are equal, and they balance each other.

As the temperature of water is raised, evaporation takes place more rapidly. However, it takes place only at the surface. When the temperature gets high enough (reaches the boiling point), evaporation takes place still more rapidly. Now evaporation occurs throughout the liquid, not merely at the surface. Water vapour in the atmosphere, of course, is part of the air. In addition to the water molecules, present also are molecules of nitrogen, oxygen, carbon dioxide, and other gases. When water vapour is at a temperature considerably above the boiling point, it is properly referred to as *steam.* Steam is a gas that is invisible and dry; it contains no water droplets.

The activities in i, ii, iii and iv above are good examples of controlled experiments. In each case, all conditions except one are kept alike. For example, on page 196 the air circulation, the area of water surface, and the dryness of the air were all kept unchanged. Only the temperature was varied. The experiment concerned this factor only. The one condition which is different in the two samples is the *experimental condition.* Point this out to the students. After they have had the teacher's help in devising one or two of these activities, they would be able to design such simple experiments themselves. Being able to design a useful investigation is a very important outcome of good science instruction.

## 4. WARM AIR CAN HOLD MORE WATER VAPOUR THAN COLD AIR

In the previous major concept, students learned that a given body of air can hold only a limited quantity of water vapour. When the air holds all the water vapour it can, it is said to be saturated. But the quantity of water necessary to saturate the air varies with different conditions of the air, particularly its temperature. Warm air can hold much more water vapour than cold air. The reasons for this are complex, but the evidence is easy to observe.

In this major concept, the relationship between air temperature and the amount of water vapour it can hold will be undertaken. In addition, the kinds of weather produced when water vapour comes out of the air as a liquid or solid will be studied.

### 4(a). SUFFICIENT COOLING CHANGES WATER VAPOUR INTO DROPLETS OF WATER OR INTO CRYSTALS OF ICE

Children have already seen through earlier experiences that water vapour can come out of the air in the form of droplets of liquid water. Almost always this change of water vapour to liquid occurs when the air is cooled. Cool air can hold less water vapour than warm air. Therefore, when moist air is cooled, it becomes more and more nearly saturated with water vapour. When it cools enough, the air becomes saturated. If the air cools still more, water vapour is changed into liquid water. If the change occurs below freezing, the water vapour becomes crystals of solid ice, in the form of snow or frost.

There are many familiar examples of water vapour changing into liquid water. Warm breath on a cold day, the appearance of a cloud or mist above a boiling pot, or the formation of fog or cloud under proper conditions, are common examples. There is no need to repeat here the activities of the previous concepts. However, the change of water vapour into liquid or solid water can be reviewed. At this class level, it should be restated something as in the previous paragraph. Children of class IV can be helped to understand the reduced ability of cool air to contain water vapour, and the concept of saturated air.

### 4(b). THE CONVERSION OF WATER VAPOUR INTO DROPS OF WATER IS CALLED CONDENSATION

When moist air is cooled below the temperature at which it is saturated, liquid water appears as tiny droplets of a mist or cloud. This process is called *condensation*. One says that the water vapour *condenses* into droplets of liquid water. If the temperature is low enough, the water vapour changes directly into crystals of ice. The four items below relate to four special cases of condensation and sublimation.

*(i) When Water Vapour condenses on cold objects, Dew is formed*

When moist air is in contact with cool surfaces, some of the air is below the saturation point. When this happens, water vapour from the air condenses on the cold surface. It becomes visible as a covering of tiny water droplets, often called *dew*. The temperature at which this occurs depends on the degree of saturation of the air. This temperature for a given sample of the air is called the *dew point*. Children should have experience with the formation of dew in this way.

**Investigation**

**How is dew formed?**

*Materials required*
**shiny metal or glass**
container,
**cold water**

Arrange a clean glass or metal container filled with cold water, if possible, ice water. Have children observe the formation of dew on the outside of the container. Help them realize that this has formed because the moist air next to the container has been cooled below the temperature at which it is saturated (below the dew point).

**Familiar Experience**

**When does dew form?**

Encourage children to observe the formation of dew in the early morning. Help them realize that the dew is formed when the night air is cooled enough for condensation to occur (it reaches the dew point).

*One usually gets some protection from rain under a tree. Discuss with children whether or not dew forms on the ground under trees. Once an opinion has been formed, check the opinion by actual observation.*

**For Better Understanding**

It is commonly said that 'dew falls'. This is not true. It forms right where it is found. Sometimes it is under trees or in other protected places where it could not possibly have fallen. Dew is most likely to form on nights when the sky is clear. Under those conditions, the earth loses heat rapidly and the air is more likely to cool down to the dew point.

*(ii) When objects are freezing cold, Frost may be formed from Water Vapour*

When air is cooled below the temperature at which it becomes saturated, it condenses. But if that temperature is below the freezing point of water (0° C), the change is directly into the solid form of water—ice. If ice and salt are available, it is possible to have children observe the formation of frost as follows.

**Investigation**

**How does frost form?**

*Materials required*
metal can or pot,
ice, salt

In a clean metal container prepare mixture of salt and ice. As this is mixed, the temperature goes lower and lower—well below the freezing point of water.

Have children observe carefully what happens on the outside of the container. At first, dew will form. Later as the sides of the container become

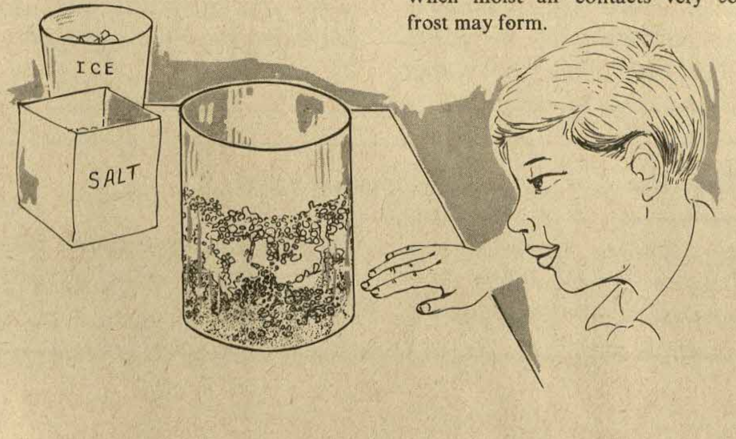


Fig. 2-50
When moist air contacts very cold surfaces, frost may form.

colder and colder, frost crystals will form, as in Fig. 2-50. Invite children to look very carefully to distinguish between real frost and the dew which has formed as a liquid and then frozen. Ask them if they can tell what is wrong with the statement, "Frost is simply frozen dew".

*Display pictures of frost formations from parts of the world where frost is common in winter.*

*(iii) When Water Vapour condenses on particles in the Air, it forms Clouds or Fog*

Water vapour almost never condenses *on nothing*. If no surface is available for the formation of dew, water vapour condenses in the form of a cloud or mist in the air. But each droplet of water forms on a particle of dust or other solid material in the air. Indeed, if the air is exceptionally clean, it may be difficult for clouds to form! This is not common knowledge among most adults. Fortunately, it is quite easy to demonstrate in this way:

**Investigation**

**Do clouds form on dust and smoke particles?**

***Materials required***
large clear glass jug,
**source of smoke**

Obtain a large clear glass jug, four or five litres in size, if possible. Wash it very clean and rinse the inside out several times with water. The inside will then remain wet, but the air will be quite clean. Now attempt to produce a cloud in the bottle as suggested in Fig. 2-51. Place the lips directly on the mouth of the bottle and blow as hard as possible. This compresses the air inside the bottle. Then release the air pressure by very suddenly removing the lips. The air inside suddenly expands and cools. The combination of expansion and cooling *should* be enough to form a visible cloud inside the bottle. Usually, however, only traces of the expected cloud can be seen.

Now put some tiny particles into the bottle. This can be easily done by permitting smoke from a match or a candle or some incense to enter the bottle while it is held upside down. This can be done in a few seconds. The amount of smoke let in should be so slight as to be scarcely visible. Now repeat the process of compressing the air within the bottle and suddenly releasing it. If done properly, a readily visible light gray mist will now be formed. The only change that has been made is the addition of fine particles on which condensation can occur. See also "For Better Understanding" at the end of this major concept

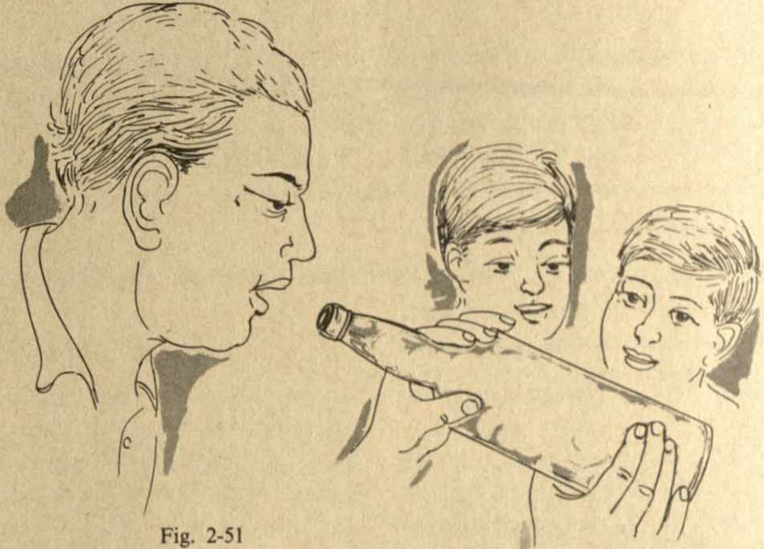


Fig. 2-51
A cloud can be formed in a glass jar; traces of dust or smoke in the glass jar permit a more dense cloud.

*Remind children that unexpected rain showers sometimes come when the air is very dusty. It may be that the high concentration of dust particles improve the chances for the formation of clouds and rain.*

### *(iv) When Water Vapour freezes in the Air, it forms into crystals of Ice*

When water vapour *condenses* on particles in the air, a cloud or fog of tiny liquid water droplets is formed. But if the temperature is low enough, sublimation occurs instead. In this way, clouds of ice crystals or snow flakes may be formed. It is almost impossible to reproduce this process in the elementary school laboratory. However, children's attention may be brought to this subject by a discussion such as this.

**Discussion**

**How does snow form?**

Engage the class in a discussion about clouds, and about fogs. Help students realize that a fog is the same as a cloud, and that each contains tiny droplets of water. (A fog is simply a cloud in contact with the earth's surface.) These droplets are so small that they are prevented from falling merely by the supporting action of molecules of air. Now call students' attention to the very high, feathery, wispy clouds known as cirrus clouds. These are made of ice crystals and/or snow crystals, because they are formed at very great altitudes where it is so cold that sublimation instead of condensation occurs.

*Display pictures of snow storms from other parts of the world. Also, show pictures of snow-flakes. Remind children that snow is extremely common in the higher latitudes and higher altitudes of India.*

**For Better Understanding**

Fog is a special form of cloud. The only difference is that fog occurs at or near the ground. Otherwise it is the same as a cloud. Fogs and clouds contain millions and millions of tiny droplets of wet, liquid water. Dark clouds (like rain clouds) are merely those which are quite thick, so that very little light gets through them. If the clouds also contain water *drops,* that too make them appear darker. The 'silver lining' of a cloud is merely that portion of the edge which is beautifully lit up by the sun or the moon.

A heavy cloud or fog contains about 1/2 gram of water droplets per cubic metre. The air in a cubic metre weighs about 1-1/4 kilograms, or about 2500 times as much as the water droplets. No wonder clouds seem to be 'weightless'.

### 5. PRECIPITATION OF WATER OCCURS IN DIFFERENT WAYS

Precipitation is the term applied to the production from the air of water in liquid or solid form. Thus, 'precipitation' includes not only clouds and fog, but also dew and frost, rain, sleet, hail, and snow. Precipitation is one factor in the total condition known as 'weather'. In this major concept, students will learn some of the more important ways in which precipitation occurs.

**5(a).** RAIN IS FORMED WHEN DROPS OF WATER IN THE CLOUD GROW TOO LARGE TO STAY UP IN THE AIR

Most clouds are made up of tiny droplets of wet, liquid water. However, these drops are so small that they are kept from falling by the motion of the molecules of surrounding air. In most clouds, these droplets do not grow any larger, so the cloud remains in the air until it evaporates. Sometimes, however, these *droplets* combine to form *drops*. These are too large to be supported by molecular motion, and they fall as rain. It is almost impossible in the primary grades to produce genuine rain as a demonstration. However, the activity which follows will help students comprehend this sub-concept.

**Investigation**

### How big are the water droplets in a cloud?

*Materials required*
pan, water,
source of heat

Prepare an artificial cloud in the classroom—such as the mist above a pan of boiling water. Invite children to examine closely the particles of which the cloud is composed. See Fig. 2-52. They will find that they cannot see the individual droplets of water even with a magnifying glass. Ask them to compare this information with what they already know about the size of typical raindrops.

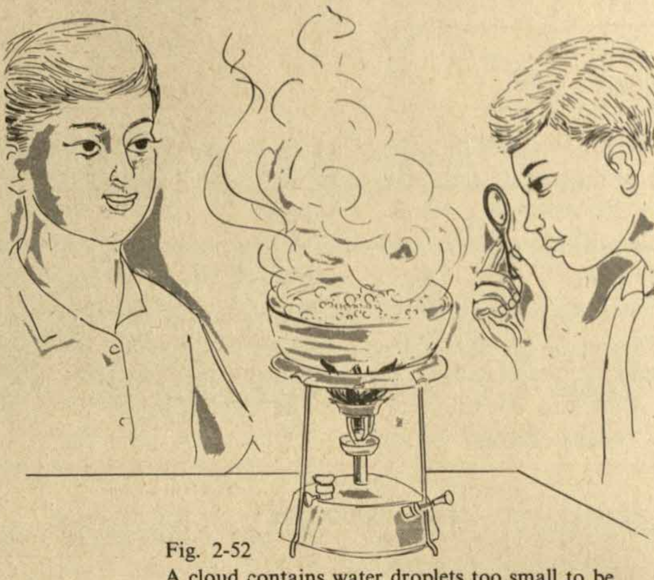


Fig. 2-52
A cloud contains water droplets too small to be seen.

*Remind children that they can sometimes see the water droplets in a mist or a drizzle. But the water droplets in a true cloud or fog are microscopic, or nearly so.*

### For Better Understanding

The exact process by which cloud droplets combine to form rain drops is not thoroughly understood. However, weather scientists are doing research to learn more about this. Already they have in some cases been able to make some clouds produce rain, or to make other clouds disappear, at least temporarily. Rain drops vary greatly in size—from less than a millimetre (like a pinhead) to a half centimetre or so in diameter. Contrary to popular opinion, rain drops are almost perfectly spherical—they are not 'streamlined'.

### 5(b). SLEET AND HAIL MAY BE FORMED WHEN RAIN DROPS FALL THROUGH COLD AIR

Sleet is literally frozen rain. Rain is formed in clouds which are warmer than freezing temperature. When these drops fall through colder layers of air, they freeze into tiny balls of ice. This is sleet.

Sometimes these bits of sleet are hurled up and down time after time, going from freezing layers of air to above-freezing layers and back again. Each time the ice particle goes through the layer of cold air, this new layer of water freezes, making the ball of ice bigger. If this happens many times, the ice-ball may become a centimetre or more in diameter. This finally falls as hail. Sometimes hail falls during the summer. This shows that even during the heat of the summer, upper layers of air may be very cold indeed.

Sleet and hail cannot be produced as a classroom activity in primary grades. However, a discussion such as this will help children understand these two sub-concepts:

**Discussion** **What are sleet and hail like?**

Ask children if they have ever seen sleet or hail. In what time of the year did this happen? Have any of their parents had experience with hail stones as big as marbles, or even bigger? Ask them to describe the difference between hail and snow.

*Display pictures of sleet and hail from colder parts of the world.*

*Tell a story about occasional hailstones which are so big that they do severe damage to fruit on trees, to grain standing in the fields, and to flying aircraft.*

### 5(c). WHEN THE AIR IS SUFFICIENTLY COLD, MINUTE ICE CRYSTALS COLLECT TOGETHER AND FALL; THIS IS CALLED SNOW

In the previous major concept, children learned that water vapour sometimes precipitates to form a cloud at sub-freezing temperatures. Under those conditions, water droplets are not formed. Instead, tiny ice crystals are produced. These clouds of ice crystals are sometimes called cirrus clouds. They are the very high wispy clouds often seen, particularly in the winter. These crystals do not fall because they are so small that they are supported by the forces of the surrounding air molecules. Sometimes these ice crystals combine and grow to form snowflakes. Snowflakes are so large that they cannot be supported by molecular motion, so they fall—usually quite slowly. Children can be given a better appreciation of snow by teacher-arranged activities such as these.

**Discussion**

**What is snow like?**

Show children pictures of snow-covered mountains and fields from many parts of the world. Read stories or poems about living conditions where snow is very common. Show pictures of the typical six-sided snowflakes. Discuss winter sports, such as skiing or ice-skating.

*Read to class an account of a mountain climbing expedition in the Himalayas. Point out that snowfall is a very common occurrence in that part of the world.*

**For Better Understanding**

Due to the structure of ice crystals, snowflakes usually form on a six-sided or hexagonal pattern. There are six-pointed stars and fancy hexagonal designs of every description. It is said that no two snowflakes are alike, but this would be difficult to prove. See Fig. 2-53.

Snowfall can take many forms. Sometimes it is hard ice crystals driven by strong winds. Sometimes the snow is mixed with sleet, or with rain. Occasionally, snowflakes cling together to form very large clumps of snow even a few centimetres long.

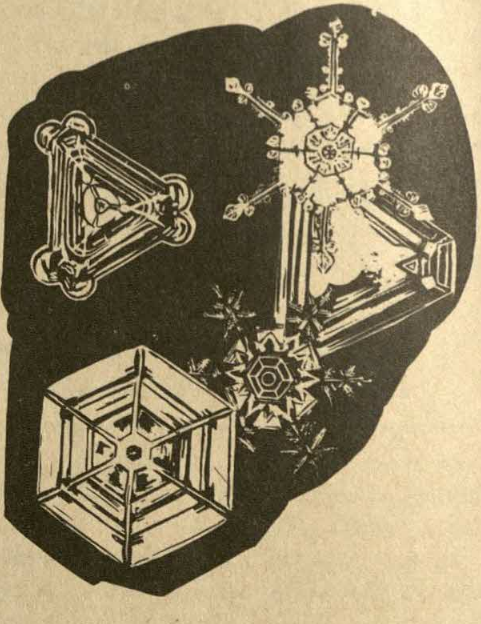


Fig. 2-53
Show-flakes form in thousands of different designs; almost all of them are based on six-sided shapes.

## 6. WATER CAN BE PURIFIED IN MANY WAYS

It is quite obvious to children that much outdoor water is dirty. However, they are often not aware that water can carry other impurities besides visible dirt. The sub-concepts which follow are intended to help children become more familiar with the many kinds of impurities which water may carry, and with simple ways in which water may be purified.

### 6(a). MANY MATERIALS ARE CARRIED BY WATER

Children readily realize that ordinary water in rivers and streams is not absolutely pure. However, they seldom realize what large quantities and varieties of materials are carried by water. In addition, they are usually aware only of those impurities which they can see. They need also to understand about the invisible impurities, such as dissolved materials and germs, which can be present even in clean water. A discussion-type activity such as that which follows can help make children aware of this:

**Discussion**

**What kinds of impurities can be carried by water?**

Engage students in a discussion about what kinds of things can be carried by water. Of course, they will mention ships and floating logs, but the place to concentrate the discussion is when they mention gravel and sand and other visible dirt—in general, *sediment*. With the teacher's encouragement they may mention that water can carry salt or sugar dissolved in it—or other materials which give it taste. Some materials in water give it odour. Now the children are talking about *invisible* materials carried by water. Close the discussion with comments about germs of various kinds—also invisible—which can be carried by water. Point out that these are usually tasteless and odourless, but that they can be extremely harmful.

*A discussion such as the above reveals a variety of impurities which can be carried by water. Encourage children to think what might be the source of each kind of impurity.*

### 6(b). MANY MATERIALS DISSOLVE IN WATER

Of all the common liquids, water is the best solvent. Children know that salt and sugar and other kinds of flavouring can be dissolved in water. They should be given a chance to find out at first hand that many other materials are also highly soluble in water. Here is an activity through which this learning can take place.

**Investigation**

### Which common materials dissolve in water?

*Materials required*
clear glass jar,
water, assorted
materials

Challenge the class to find out for themselves which common materials from around the home and community are soluble in water. Tell them they cannot ask anyone else—they must find out for themselves. The way to do it, of course, is to try it out and see, as in Fig. 2-54. Encourage them to try not only salt and sugar, but also materials like stone, chalk, glass, plastic, flour, wood, phitkari (alum), lime, various metals, soap, and the like. They can also try common liquids, such as syrup, kerosene, vinegar, alcohol (spirits), or cooking oil. In some cases, there will be disagreement as to whether or not the material actually dissolves. The decision may be a difficult one, but it is not impossible. In this activity, the important object is to see that there are many, many materials which are at least slightly soluble in water.

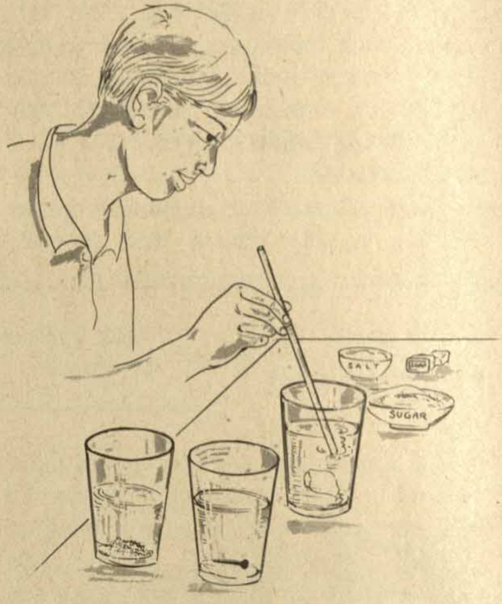


Fig. 2-54
Children can find out for themselves which materials are readily soluble in water.

*See how much salt can be dissolved in a small jar of water. Show that there is a limit to the amount of salt which can dissolve.*

**For Better Understanding**

A great many materials are *slightly* soluble in water—at least enough to give a noticeable taste. This is true of chalk, or of oil, for example. Actually, even some materials like glass and rock are slightly soluble in water. The taste of drinking water is usually given by traces of dissolved material—traces too small to be measured except by very sensitive chemical tests. Gases also dissolve in water. Fish breathe oxygen which is so dissolved. Carbon dioxide, dissolved in water under mild pressure, provides the carbonation of many kinds of soft drinks.

### 6(c). SEDIMENTATION, DECANTATION AND FILTRATION OFTEN REMOVE SUSPENDED IMPURITIES

Some materials do not dissolve in water, but remain there as a *suspension* of extremely finely divided particles. Some materials like milk and paint owe their appearance to such particles. Water which is slightly cloudy has such suspended particles, although they are far fewer in number.

There are several ways in which such particles can be removed from water. One of these is *sedimentation*. In this process, impure water is simply allowed to set for a long time, so that even finely divided particles have a chance to settle down. Sometimes this settling is hastened by adding some material which slowly sinks through the water and carries suspended particles with it. This process can be made more clear through an experimental activity such as this:

**Investigation** **How can sedimentation be hastened?**

*Materials required*
pail, two identical clear glass jars, chalk dust or powdered clay, phitkari (alum), water

Make a pail of water slightly cloudy by mixing in it a few spoons of finely divided clay or chalk dust or something similar. Put equal quantities of this dirty water into two identical glass containers. Place them in a location where they can be watched, but would not be moved in any way. Allow one simply to settle; it may take several days for water to become reasonably clear. To the other container, add some finely powdered phitkari (alum). See Fig. 2-55. Only a pinch of this is needed; it should be gently sprinkled on the surface of the water—*not* stirred in. Have the children observe which container of water clears more rapidly. Encourage them to describe how the addition of the alum has hastened the process of sedimentation.

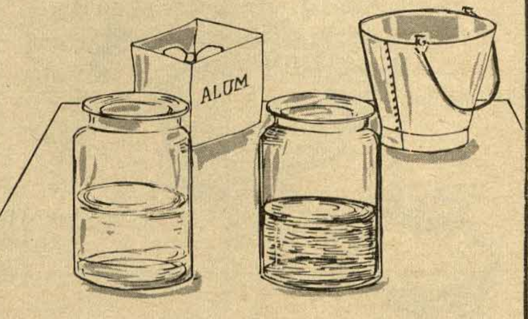


Fig. 2-55
Suitable chemicals hasten the process of sedimentation.

*Compare the rate of sedimentation of finely divided material, such as chalk dust, with that of sand. What is the relation between the rate of sedimentation and the size of the particles of impurity?*

Another technique for separating water from impurities is *decantation*. This is a process of gently pouring off clear water and leaving the unwanted sediments behind. Very simple activities like these will help the children appreciate the process of decantation.

**Investigation**

**How are liquids decanted?**

*Materials required*
two clear glass jars, sand, water

Challenge children to separate water from sand which has been mixed into it. Many children will see immediately how to do this. They allow the sand to settle, then gently pour off the nearly clear liquid, leaving the sand behind as in Fig. 2-56. This is the process of *decantation*. This can also be applied to the cloudy water which has undergone sedimentation in the activity immediately above.

Fig. 2-56
Some impurities can be separated from water by decantation.

*Make some tea in the classroom. When the leaves have settled, show children how clear tea can be decanted out of the pot, leaving the leaves behind.*

Filtering is an easy but important process both around the home and in the science laboratory. In this process, one pours a liquid with undissolved impurities through a filter material such as cloth, porous paper, or even sand or earth. The undissolved materials do not go through the filter, but remain behind. Children should be encouraged to experiment with the filtering process, like this.

**Investigation**

**How are impurities filtered from liquids?**

*Materials required*
glass jar, water, dirt, cloth for filter

Challenge children to use filtration to separate water from a handful of earth which has been mixed in it. Let them use any filter material they choose, like a simple cloth filter, as in Fig. 2-57. In most cases, there will be some cloudiness still in the filtered water. This is due to the suspended material, that is so fine that it goes right through the filter. Suggest that children similarly try to separate the white suspended solid material from milk. Point out that on a large scale, a sieve is really a kind of filter.

Fig. 2-57
Some impurities can be removed from water by filtering.

*Prepare a pot of tea in the classroom. Pour it through a sieve to hold back the leaves. Point out that this is a form of filtering.*

### For Better Understanding

In practice, scientists use combinations of the methods mentioned above and others for separating water from solid materials mixed in it. A centrifuge is an interesting example of such separation. If given time, cream separates from milk because the milk is more dense than cream and goes to the bottom. This difference in density is exaggerated in a centrifuge. By whirling containers of milk rapidly in a rotating frame, the process of separation can be effectively carried out in a few minutes. See Figs. 2-58a and 2-58b.

In water purification systems, sedimentation is carried out where necessary. Filtering is sometimes done, too, usually through very large filters made up mostly of fine sand.

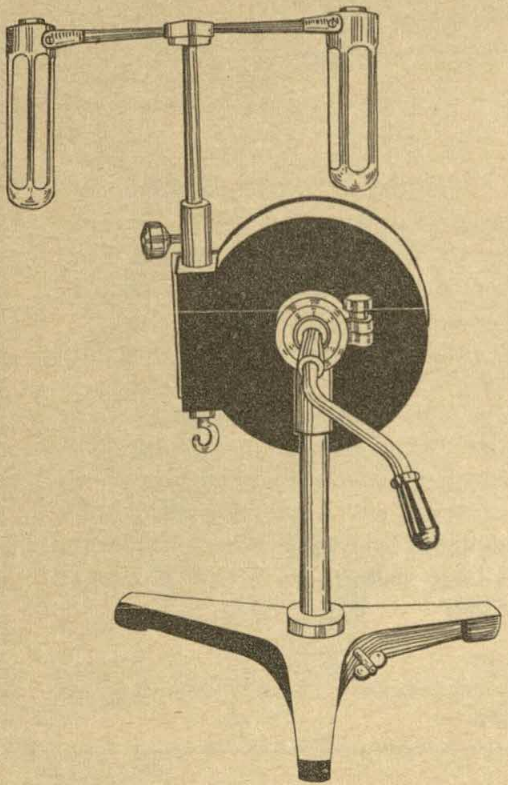


Fig. 2-58a

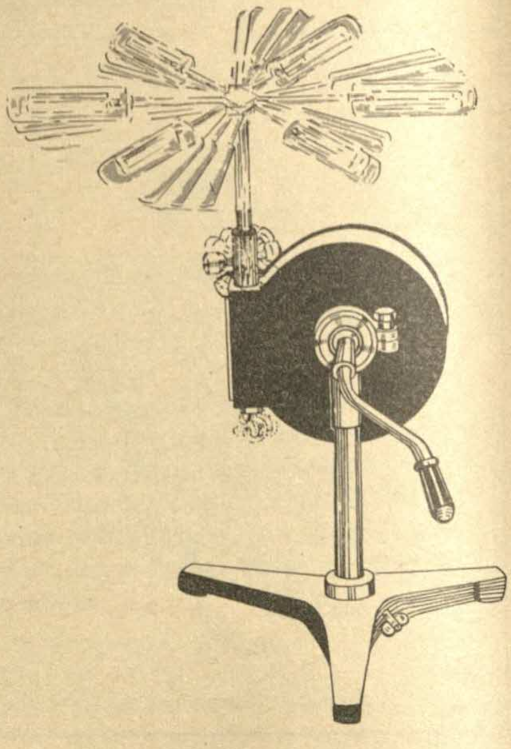


Fig. 2-58b

A centrifuge can hasten separation by sedimentation.

6(d). RAIN WATER IS USUALLY CLEAN

Children have already learned that water droplets of clouds form on a particle of dust or other solid material in the air. This material is therefore present in normal rain. Actually, this amount of impurity in rain water is extremely slight. In general, rain water is very clean until it reaches the ground. Here are activities which can make this point clear to children.

**Investigation**

**How clean is rain water?**

*Materials required*
clear glass container,
rain water,
magnifying glass (if possible)

Urge children to get rain water in very clean containers. Let them examine it closely for visible impurities. Usually, they find none at all. Let them taste the water to see if they can detect anything unusual. Rain water usually seems to taste 'flat'. This is not due to the presence of some impurity, but to the *lack* of it. The 'taste' of normal drinking water is due to traces of dissolved materials. These are almost completely lacking in rain water.

Sometimes, when it rains just after a dust storm, rain water contains visible amount of impurities.

*Heat a small sample of rain water in a clear glass dish. When the water has evaporated, is there any scum remaining in the dish? Is 'clean rain water'* absolutely clean?

**For Better Understanding**

In some parts of the world, rain water is collected on a large scale for drinking purposes. In some island communities, for example, there is no fresh (non-salty) well water. In some such places, roofs of buildings are kept extremely clean, and rain water running from them is collected and stored for human consumption.

Germs in drinking water are the most dangerous form of impurity. Water which contains germs can usually be made safe to drink by vigorous boiling for twenty minutes. Even though the water may be dirty in appearance and have a strange taste, water so boiled is almost always safe to drink.

## 7. WATER IS PRESENT UNDER GROUND

In class II of this unit, children have become aware that water is sometimes obtained from underground sources. They have carried out activities related to water from springs and wells. They are somewhat familiar with the concept of the water table, even though they may not use the specific term. Here in class IV, they can learn more about how water moves under ground and how the water table is formed.

### 7(a). WATER PASSES THROUGH POROUS MATERIALS

Children know from experience that water passes through many materials. This is obvious for materials with visible holes, such as screen-wire or cloth. However, children often need help in realizing that when water simply *seeps* through a porous (or leaky) material, this is still a matter of 'passing through', even though the flow of water is slow. They can be helped to grasp this concept through activities such as these.

**Investigation**

### How does water pass through porous materials?

*Materials required*
cloth or porous paper,
lamp chimney,
water

Prepare a porous pad from several layers of blotting paper, paper towels, or cloth. The pad should be a centimetre thick or more. Now press firmly the bottom edge of a clean lamp chimney against this porous material, as in Fig. 2-59. Help students realize that this is a glass container with a porous bottom. Ask them whether or not it will hold water. Some will say, yes, others, no. Some will say that it will leak. Now add water to see what happens. Help children appreciate that water is actually flowing through the porous material. This is often called *seeping* or *leaking*, but really it is flowing very slowly. Ask children what other materials might also permit water to flow in this slow manner. They will suggest thin layers of wood, sponge, layers of sand, and the like. These might be tried using the same general procedure. If possible, show them a piece of pumice rock which is also porous. Help them realize that certain kinds of rock are porous.

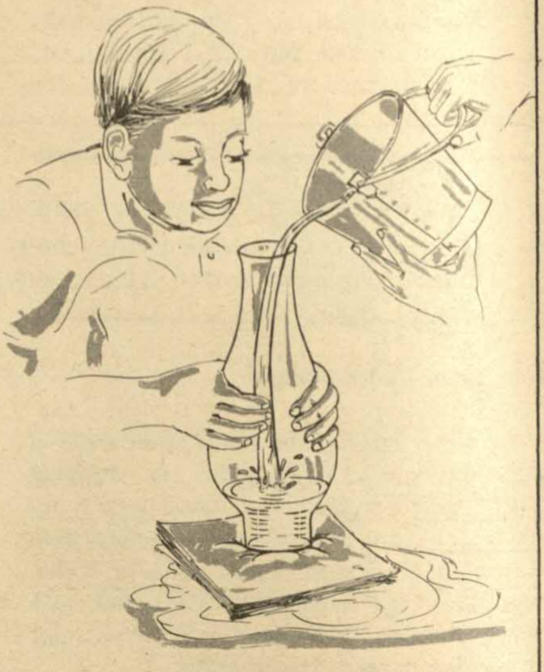


Fig. 2-59
Many porous materials permit water to pass through slowly.

*Demonstrate water seepage through a fresh earthen jug. Challenge children to predict how long it will take for all the water to seep out. Now try it to check their predictions. Be sure to cover the jug's mouth to prevent evaporation.*

*Remind children how water seeps through porous materials like leather water-bags, brick walls, and plaster.*

7(b). WATER IS STOPPED BY NON-POROUS ROCKS

Students are well aware that a solid rock will not permit water to flow through, even slowly. What they do not realize is that large masses of solid rock—like the earth's bedrock—have many cracks. Activities such as the following are useful in helping students see how water behaves when it encounters a solid rock.

**Investigation**

**Does water pass through a solid rock?**

***Materials required***
solid stone dish,
cracked cup or earthen jar,
water

Obtain a solid stone dish. It may be a very shallow tray. Put water in it and ask the students whether or not it will leak. Allow it to stand for several days to see whether or not their predictions are correct. Now ask them what would happen if the stone dish had a large crack in it. Perhaps a cracked dish can be found. A badly cracked tea cup serves very well. A non-porous earthen jug may be deliberately broken and tied back together to serve as a model for a cracked stone container. Again try the experiment using a container which is cracked enough to permit such a leakage-flow. Ask children if they believe that layers of rock under ground are completely free of cracks. Help them realize that as a rule, even the earth made of non-porous rock permits at least a little water to flow through it.

*Challenge children to find layers of rock in the earth which are free from cracks. Usually, it is impossible to find large pieces of rock which have no cracks.*

7(c). THE LEVEL OF WATER (WATER TABLE) BELOW THE GROUND MAY BE LOW OR HIGH

Almost all kinds of earth material—particularly gravel and sand—permit water to flow slowly through them. As a result, there is moisture under ground in almost all parts of the earth. The earth is saturated with water up to a certain level. This level is known as the *water table*. In some places, the water table is hundreds of metres below the ground. In others, the water table is very near the earth's surface—sometimes right *at* the surface. The level of the water table often varies considerably from one time of the year to another. Here are activities which can help students grasp a good understanding of the nature of the water table.

**Investigation**

## What is the water table?

*Materials required*
large clear glass jar,
coarse sand,
water

Place coarse sand to a depth of several centimetres in a glass aquarium or a large glass jar. Point out that this is to be a model of porous earth. Very slowly—so as to avoid splashing and eroding—pour water at one extreme side of the container. Permit students to see how the water slowly flows through the porous sand, as in Fig. 2-60. Can they see that the lower layer of the sand soon becomes saturated with water? This corresponds to the water table. Add more water. Can students see that the water table now rises?

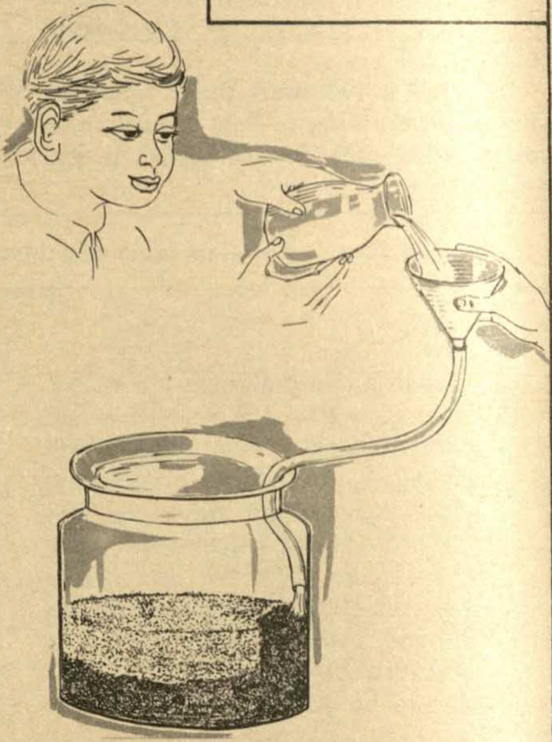


Fig. 2-60
The water table can be understood with the help of a simple model.

**Discussion**

## How is the water table related to wells?

Engage students in a discussion about the water level in wells in the community. Remind them that a well is merely a hole in the earth, dug below the level of the water table. The level of water in the well is at the top of the water table in the surrounding earth. As the well-water level changes, it indicates variations in the level of the surrounding water table. At what times of the year is the local water table highest, lowest? What is the result if the water table sinks below the level of the bottom of the well?

*Dig a small hole a metre or less from the pond or lake. Does water seep into the hole? Has the hole gone below the water table?*

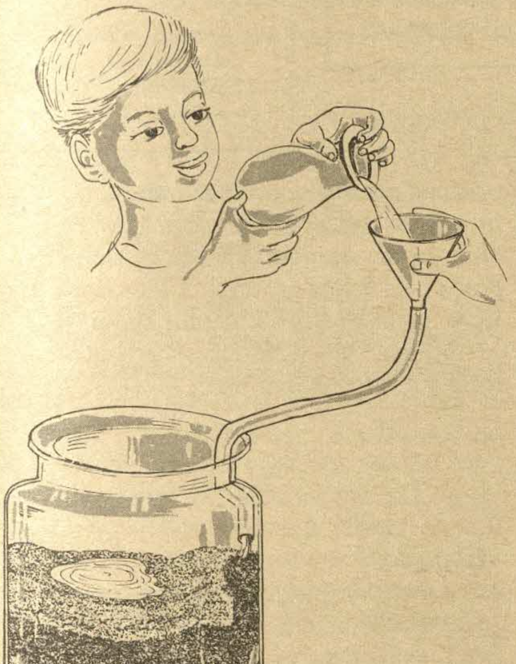
### 7(d). SWAMPS ARE FORMED WHEN THE WATER TABLE IS CLOSE TO THE SURFACE OF THE GROUND

In some places, the water table comes very close to the surface of the ground. The soil there becomes extremely moist. Usually, this forms a swamp. Indeed, if a swamp has water standing in it, the water table at that place is actually above the surface of the ground. When the water table goes down, the swamp grows smaller, or even dries up. Children can be helped to understand the relation between the water table and swamp land through an activity such as this.

**Investigation**

**How is a swamp formed?**

*Materials required*
clear glass jar,
sand,
water



Arrange sand in a glass container in the manner of the first activity under sub-concept 7(c) above. This time, arrange a depression in the surface of the sand, as in Fig. 2-61. This depression should be well away from the place where the water is added to the model. As the water is added and the water table rises, have students note how the sand in the depression becomes moist. Help them realize that this—in the model—is a swamp. If the water level rises still more, the swamp becomes a pond or even a lake.

Fig. 2-61
When the ground level dips down slightly below the water level, a swamp, a marsh, or a shallow pond is formed.

*Call students' attention to a seasonal pond or lake in the vicinity. Just after the monsoons, the pond or lake is large, because the water table is high. As the dry months come, the water table goes lower, and the pond or lake becomes smaller. Sometimes it disappears altogether.*

### 7(e). WATER MAY BE OBTAINED FROM BELOW THE WATER TABLE IN WELLS OR SPRINGS

Children already know that wells are holes dug deeper than the level of the water table. Springs are more difficult to understand. Sometimes water is trapped in a porous rock between the layers of a non-porous rock. This water may be under pressure. The pressure is produced by the water table being higher a long distance away—often a few kilometres or more. If there are cracks in the non-porous rock, the water trapped within may flow out at the surface of the ground, forming a natural spring. Here are activities which will help children see how wells provide water.

**Investigation**

**What is the source of well water?**

*Materials required*
clear glass jar,
coarse sand,
water

Again use the model made with sand in a glass container. Arrange a water table in the model. Now dig a small hole down below the level of the water table, as in Fig. 2-62. Permit children to see how the hole fills with water from the surrounding water table.

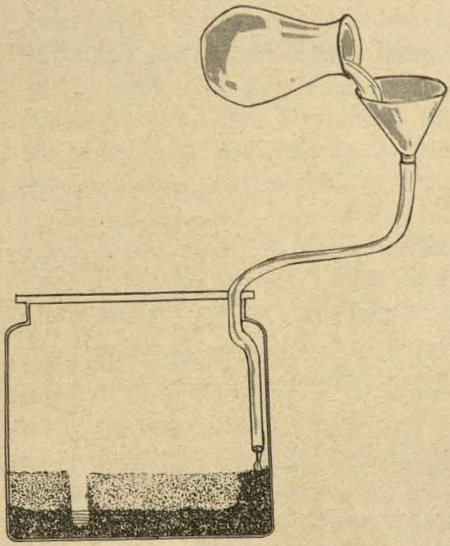


Fig. 2-62
When a well is dug below the water table, water seeps into the well.

*Visit a nearby well, if possible, one which is just being dug. Discuss it with students in terms of the water table, water seeping through a porous rock, and other such concepts.*

It is difficult to make working models of springs or artisan wells in the classroom. However, a planned discussion such as suggested here can help students become more familiar with such sources of water.

**Interview**

**What can we find out about springs?**

Encourage children to ask their parents to tell them of springs which they might have seen. Do springs deliver water uniformly throughout the year, or do they vary from season to season? If there is a spring in the community, find out how dependable it is. Is there any higher land nearby from which the water is supplied?

*Display pictures of natural springs. See if there is an artisan well which children can visit, or about which you can tell them.*

## For Better Understanding

Most of the learnings in this class level have been related to various kinds of changes of water. Evaporation of water has been taken up in detail, and also its precipitation in various forms of weather. The storage of water under ground has been studied, and the availability of water from the water table has been considered. These are all portions of the endless cycle of events which takes water from the ground into the air as water vapour, out of the air as some form of precipitation, and back to earth again. This cycle of events is known as the *water cycle.*

Teachers should present the material of this unit in such a way as to illustrate the water cycle. Children should be helped to understand—in terms of the water cycle—where rain comes from, why rivers do not dry up permanently, and why wells seldom run dry. They can see that by understanding the water cycle, man can improve his water supply. They can also see that the water cycle can be interrupted, as by removing all vegetation from a large area so that water does not remain there long enough to sink into the ground. In such cases, man's supply of ground water may fail.

Children may be encouraged to wonder about the source of energy for the endless changes of the water cycle. This source of energy has been discussed in major concept 1 of this unit. It is the sun. The sun provides heat energy for evaporation, and it is solar energy which produces winds. The earth has sometimes been described as a giant heat-engine. As such, it converts solar energy into the many energetic forms of weather.

# UNIT 2

INSTITUTE OF EDUCATION FOR WOMEN
Dept. of Extension
SERVICE
CALCUTTA-27

# AIR, WATER AND WEATHER

## CLASS V

### Overview

Like any other living organism, man interacts with other living things, and also with non-living parts of his environment. Among the non-living things in the environment, air, water and weather play an important role. Primitive man could exist only where conditions of air, water and weather were favourable. As population and civilization grew, man has become more and more a master of his environment. He can now control the temperature as he wants, and can purify and store water for use when and where needed. Year by year man is becoming more and more competent in predicting the patterns of weather. Gradually, he is beginning to understand the principles involved in controlling certain aspects of the weather. Man studies air, water and weather so that he can more effectively use and control these aspects of his environment.

Besides understanding more about air, water, and weather, primary students working in this unit also have a chance to become acquainted with certain fundamental principles of physics and chemistry. These are of value in understanding the materials of the unit and are also useful in preparing the student for later, more specialized learnings in these fields. This is particularly the case here at class V level. These students learn about pressure exerted by air, and how this pressure can be used in common devices. The pressure exerted by water under various conditions is also studied. In terms of simple chemistry, students here learn about the more important elements and compounds present in the atmosphere. They also study the ability of water to dissolve various substances.

At this class level, major concepts 2, 3, 4 and 6 involve fundamental physical principles, and should receive the major part of the teacher's and students' attention. Oyer and above these specific principles, however, students should finish class V with the understanding that air, water and weather are three aspects of the physical environment. They interact on each other. They affect man, and they are affected by man. In so doing they conform to and illustrate certain fundamental principles of physical science.

### 1. AIR IS USED TO INFLATE THINGS

Children and adults alike know that they often inflate things—'blow them up'— with air. When they see a tyre or a football or a balloon—or even a paper bag—inflated, they are seeing the result of air pressure inside the inflated object. The object feels hard —it resists being compressed or dented— because of the air pressure inside it. Students at this class level are well aware that air is a material substance. Now they can see that this material substance exerts pressure. This is the understanding which underlies this major concept—not merely that objects can be inflated, but rather that air can exert pressure—sometimes very great pressure.

### 1(a). AIR CAN BE BLOWN INTO A BALLOON OR AIR MATTRESS

Students in class V should have a chance to handle air *as a material substance*. They need first-hand experiences through which they become increasingly familiar with air and air pressure. One group of such experiences involves inflating objects with air under low pressure. Often this is done simply with the mouth. Here are some such activities:

**Investigation**

**How do we know if there is air in a balloon?**

*Material required*
**rubber balloon or plastic bag**

Obtain a large rubber balloon or a plastic bag. Permit a student to inflate one of these with air from his lungs. If air is invisible and ordinary weighing techniques cannot detect it, engage the class in a discussion on how they know that air is inside the object. Help them realize that they know of the presence of the air because of the pressure it exerts on the container. This pressure involves a force which pushes out on the container's walls. Pressure and force are closely related concepts. (See also 'For Better Understanding' at page 224.)

*In a similar manner, inflate a plastic bag or a paper bag.*

*Blow soap bubbles. Discuss with students the air which inflates them.*

### 1(b). AIR CAN BE PUMPED INTO THE BLADDER OF A FOOTBALL OR A TYRE

The second set of experiences with air pressure concerns objects which are inflated with a pump of some kind. These usually involve pressure much higher than can be developed by the lungs and mouth. Instead, a pump is used, operated either by hand or by some kind of motor. Because cycle tyre pumps are very common, they provide the means for inflation activities in the classroom at reasonably high pressure.

**Investigation**

## How can air be controlled with a pump?

*Materials required*
cycle pump,
tyre or football

Permit a child to use a cycle tyre pump to inflate either a cycle tyre or a football. Point out to the class that as he operates the pump, he is applying force to make air go into the tyre. The greater the pressure grows in the tyre, the greater is the force he must use to continue to inflate it. When inflation is complete, invite students to poke the tyre or the ball with their fingers, or to sit or stand on it, as in Figs. 2-63a and b. Help them realize that the pressure inside is able to resist great force from outside.

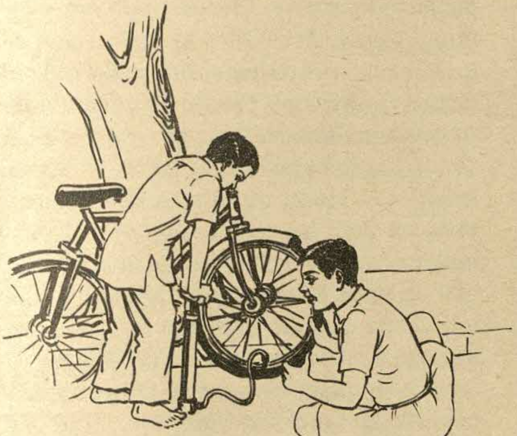


Fig. 2-63 a

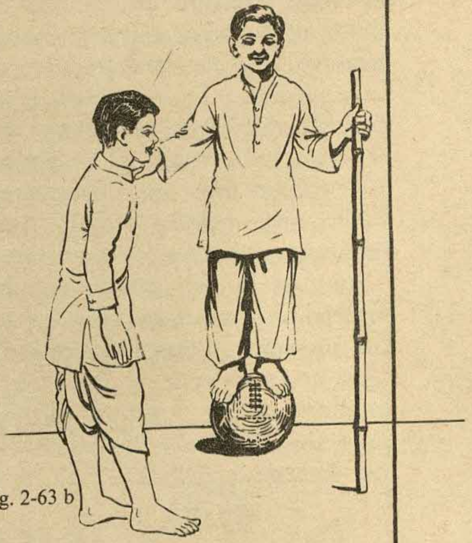


Fig. 2-63 b

A pump can handle air under fairly high pressure.

*Challenge a child to compress air into a bottle with his lungs; the more air he blows in, the greater becomes the pressure.*

*Take a cycle tyre pump apart and see how it works.*

### For Better Understanding

When more and more air is crowded into a limited space, more and more molecules get crowded together. With more molecules to hit the walls of the container, the pressure inside the container increases. Thus, pressure is a matter of molecular bombardment.

*Pressure* and *force* are closely related, although they are not the same thing. Force is sometimes referred to as a *push* or a *pull.* A force changes the motion or the shape of an object. Pressure, on the other hand, is a matter of force per unit area. Force may be measured in kilograms of force or grammes of force. Pressure is measured in terms of kilograms of force per square centimetre, or some such term. Although in general conversation force and pressure are sometimes used interchangeably, there is an important difference between the two.

Students in the activities of this major concept have been working with relatively low pressures. Pressures produced by the lungs are seldom more than two or three grammes of force per square centimetre more than normal air pressure. Footballs are sometimes inflated to a pressure of perhaps one kilogram of force per square centimetre above normal. Small tyres are often at a pressure of some two kilograms of force per square centimetre above normal. Tyres of large, heavy duty trucks may have pressures twice as great, or even more.

Notice that the paragraph above refers to pressure 'above normal'. But what is 'normal'? The normal air of the everyday atmosphere exerts a pressure of just under one kilogram of force per square centimetre ($1 kgf/cm^2$). People do not notice this pressure, because they are accustomed to it. Even so, students should be reminded of this normal air pressure. In speaking of pressure inside a balloon or tyre, the teacher should not imply that there is pressure inside and none outside. Rather, there is pressure both inside and outside the inflated balloon and tyre. That on the inside may be two or three kilograms of force per square centimetre, while that on the outside is usually a little less than one kilogram of force per square centimetre. The concept of normal air pressure will be increasingly used in other major concepts of this unit.

## 2. AIR PRESSURE CAN MOVE LIQUIDS

By now, students are aware that air, although invisible and often unnoticed, is a real substance. They also realize that air can exert pressure. In the previous major concept, they have learned that normal atmospheric pressure—the pressure of ordinary air—is nearly one kilogram of force per square centimetre ($1\ kgf/cm^2$). They must keep the presence of such normal air pressure in mind to understand this next major concept. The teacher should begin this part of the work by making sure that all students are aware of normal air pressure. If there is any uncertainty about this understanding, it should be cleared up before going any farther.

### 2(a). AIR IS REMOVED FROM A STRAW WHILE IT IS USED FOR DRINKING; NORMAL AIR PRESSURE THEN FORCES THE LIQUID UP

All children have seen people sipping liquids through a straw. Sometimes a real straw, the 'stem' of wheat, for example, is used. More commonly, the straw is of paper or plastic. Children and adults usually describe this process in terms of a person 'sucking the liquid' up through the straw. Actually, such a phrase is misleading. It is much better to think of the liquid as being forced upward through the straw by normal outside air pressure. Here are some activities which will help students understand this important point about the way air pressure can move liquids.

**Investigation**

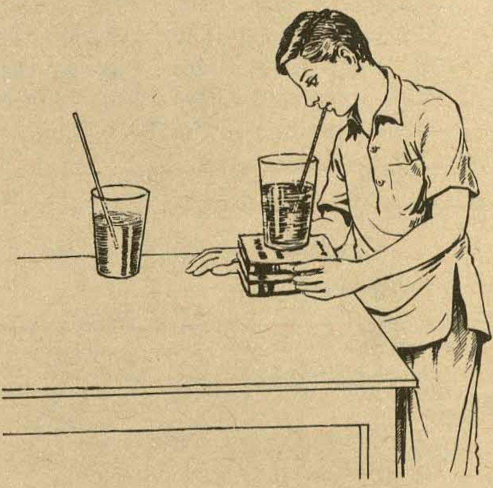
### How can liquids be sipped through a straw?

*Materials required*
drinking straw,
drinking glass,
coloured water

Invite a student to use a drinking straw to sip some coloured liquid from a container. If possible, use a transparent plastic straw. As the class discusses what happens, discourage them from describing the action in terms of 'sucking', or of the liquid being 'pulled up' by a partial vacuum inside the straw. Help them understand what happens with the aid of a sketch something like that shown. Point out that the normal air pressure outside the straw is about one kilogram of force per square centimetre (1 kgf/cm$^2$) This pressure is exerted on all surfaces, including the surface of the water. If the straw is open at the top, the same pressure is also applied to the surface of the liquid inside the straw. What happens when the demonstrating student starts to sip the liquid through the straw? The pressure inside the liquid is now reduced perhaps to 9/10 kgf/cm$^2$. The pressure on the outside is now greater and forces the liquid up in the straw. See Fig. 2-64.

Students may be helped to see how the person sipping the liquid produces a reduced pressure inside the straw. The tongue is like the piston of a simple pump. As the tongue is pulled back, the volume inside the mouth increases. As a result, the molecules are somewhat separated, and there are fewer of them per cubic centimetre. This is true in the mouth and also in the straw. The reduced number of molecules exert a reduced pressure. Help students see that this chain of events is just the opposite of that mentioned

Fig. 2-64
Liquids can be forced up a drinking straw by normal air pressure outside the straw.



in connection with the cycle pump of the preceding major concept. There the volume was decreased and the pressure went up. Here the volume is increased and the pressure goes down.

**Investigation**

**What is the pressure inside a drinking straw?**

*Materials required*
drinking straw,
drinking glass,
coloured water,
pin

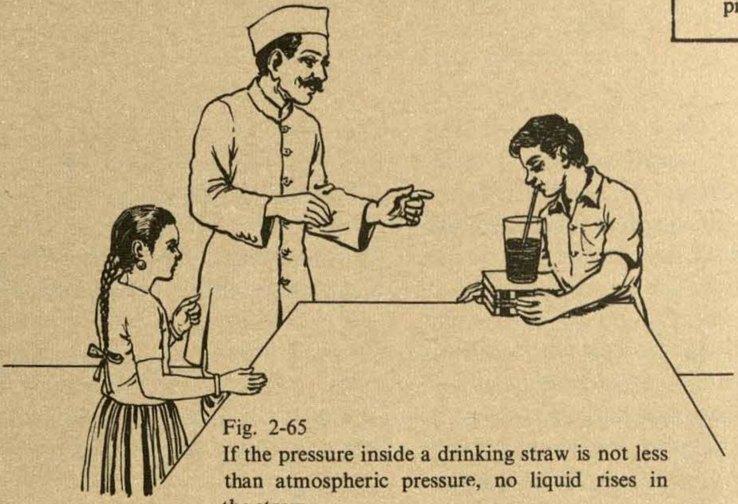


Fig. 2-65
If the pressure inside a drinking straw is not less than atmospheric pressure, no liquid rises in the straw.

Invite another student to sip liquid through a paper or plastic straw. While he is doing so, use a straight pin to punch a small hole through the straw between his lips and the surface of the liquid, as in Fig. 2-65. Observe what happens. Help the class to understand that the pinhole 'leak' in the straw prevents the student from maintaining a reduced pressure inside the straw. As a result, he is unable to lift the liquid to his mouth.

*Challenge students to see how they can lift water by sucking through a tube.*

*Use wax or gum to seal a straw into the top of a bottle completely full of water. Ask a student to suck the water up through the straw.*

### 2(b). AIR IS REMOVED FROM AN INK FILLER OR A SYRINGE BEFORE USING IT; NORMAL AIR PRESSURE THEN FORCES THE LIQUID UP

The operation of an ink filler or a syringe is almost identical with that of a drinking straw. Both operate because normal air pressure on the outside of the tube forces the liquid up when the pressure inside the tube is reduced. In the case of the straw, the pressure is reduced by the drinker who increases the volume inside his mouth. In the case of the ink filler or syringe, the air inside is first expelled. Then, when the bulb resumes its normal volume, the pressure inside is reduced. Activities such as those below will help students understand how these devices operate.

**Investigation**

**How does a syringe operate?**

*Materials required*
syringe,
drinking glass,
water

Obtain a syringe for experimental use, or take the filler out from a fountain pen so that the whole class can see it operate. Have one student operate the syringe very slowly, while the class observes carefully. Challenge them to describe exactly what they see. They should also explain what happens in terms of what they *do not see* (the change in air pressure).

*Puncture a hollow rubber ball, like a tennis ball. Squeeze it tightly and submerge it in water. Help the class explain the result.*

### 2(c). AIR PRESSURE RAISES LIQUIDS IN COMMON LIFT PUMPS

A common lift pump operates on the same principle as the drinking straw, the fountain pen filler, or the syringe. In the case of the lift pump, the pressure is reduced inside the pump system by the movement of a piston. See Fig. 2-66. As the piston is raised, the volume inside the pump is increased, and the pressure therefore reduced. A system of automatically operating valves permits repeated strokes of the piston by an up and down motion of the pump handle. Activities such as these will help students have a better understanding of how lift pumps operate.

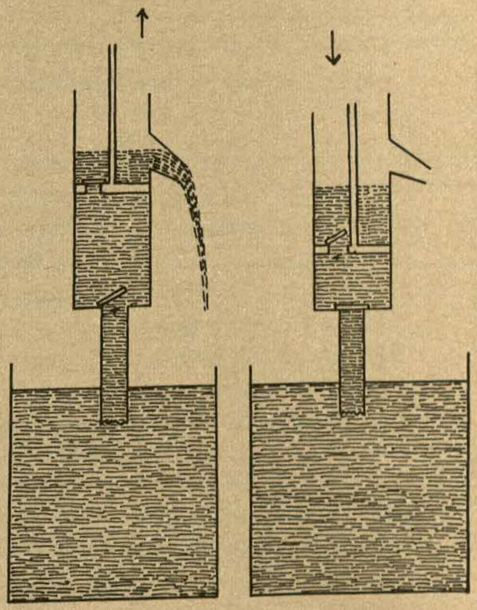


Fig. 2-66

A lift pump operates because of the reduced pressure inside the chamber.

**Field Observation**

**Let us see a lift pump in action**

Visit a well where a lift pump is in use. Permit students to do some of the pumping themselves. Request the owner to take the pump apart so that students can see the washer which makes a tight seal between the piston and the cylinder of the pump. Help them realize when and why it is necessary to pour some water into the pump. Help them see the two valves in the pump and understand how they operate automatically.

**Discussion**

**How does a lift pump operate ?**

With the student's help, prepare two large versions of the sketches of a lift pump, as shown in Fig. 2-66. Note that the first one is labelled 'piston moving upward', while the second is labelled 'piston moving downward'. Note also the position of the valves in each sketch. Help children understand what makes the valves open and close at the proper time.

*Read about the principle of the lift pump, as developed by Torricelli and Galileo (see 'Scientists at Work' below).*

*Read about barometers. Help students make a simple barometer.*

**Scientists at Work**

**Two Italian scientists solve the mystery of the lift pump**

Lift pumps have been in use for many hundreds of years. Less than four centuries ago, however, the leading scientists of the world had only an inaccurate idea of how the lift pump worked. They knew that when the piston of a lift pump rises, there is a partial vacuum (reduced pressure) in the pump chamber below it. But, they argued, "Nature abhors a vacuum". Because a vacuum was thought to be an *unnatural* condition, these scientists thought that something must happen to prevent the vacuum. The thing most likely to happen was that water would rise into the chamber—and that was how the pump worked.

At that time 'nature' was thought of almost as a person, with a mind and will power of its own. It followed certain rules. Even today some people carelessly refer to 'Mother Nature' as though it were a living being.

In central Europe, however, a seventeenth century ruler was having trouble with the lift pumps in his courtyard. Although they were very well made, they simply did not seem to work. He sought the advice of a brilliant young Italian scientist, Torricelli. He was a student of the aging Galileo. Torricelli thought that maybe "Nature does not really abhor a vacuum under all conditions!" He set about to investigate the existing theory of how lift pumps operate.

Torricelli obtained lift pumps and tried them out under many conditions. He found that they worked as expected unless the distance to lift the water was more than about nine metres. Evidently the old explanation was wrong. Torricelli continued to study the situation and learned more and more about pumps—and about air pressure. He went on to produce a nearly perfect vacuum, and developed the principle of the mercury barometer in the form that it is used today.

As for the royal lift pumps that would not work, Torricelli rejected the notion that "Nature abhors a vacuum", and that water was literally 'sucked' up by the pump. Rather, he reasoned, as we do today, that normal air pressure outside the pump pushes water up. Therefore, the distance to which water could be pushed up would be limited by the magnitude of the air pressure. Evidently, normal air pressure could not push water above a height of about nine metres. Today, it is known that if a lift pump were completely without leaks and could produce a perfect vacuum, normal air pressure could push water up to a height of about eleven metres.

Beside his accomplishments with the lift pump and the barometer, Torricelli made another most important contribution to man's understanding of science. He removed 'the will of nature' from the explanation of the lift pump. Partly as a result of this, modern people the world over have a different idea about nature than they had a few centuries ago. Today, we no longer think of 'Mother Nature' as something like a person, with will power, ability to think, and rules which must be obeyed. Of course, we appreciate the many benefits which we get from nature. We enjoy nature for what it is—a collection of the plants and animals, rocks and soils, air and water and weather and energy which surround us all the time.

### 2(d). AIR PRESSURE FORCES LIQUID THROUGH A SIPHON

Almost all children and adults have used a siphon—or have at least seen one in operation. Most people know that the output end must be lower than the level of the liquid in the source. But few people really understand why this is so. Here are two different kinds of activities which will help students understand siphon operation.

**Investigation**

## How does a siphon operate?

*Materials required*
transparent flexible tubing, pan, coloured water

Use flexible tubing—transparent, if possible—to siphon water in the classroom, as in Fig. 2-67. Have children note carefully how the siphon is started. (The tube must be filled and the output end placed lower than the supply level.) There are many ways of filling the tube. Challenge students to 'invent' as many ways of starting the siphon as possible. Ask them to predict a way in which the siphon can be made to flow faster (use a larger tube, or lower the output end.) When the predictions are made, help students check their predictions by experiment.

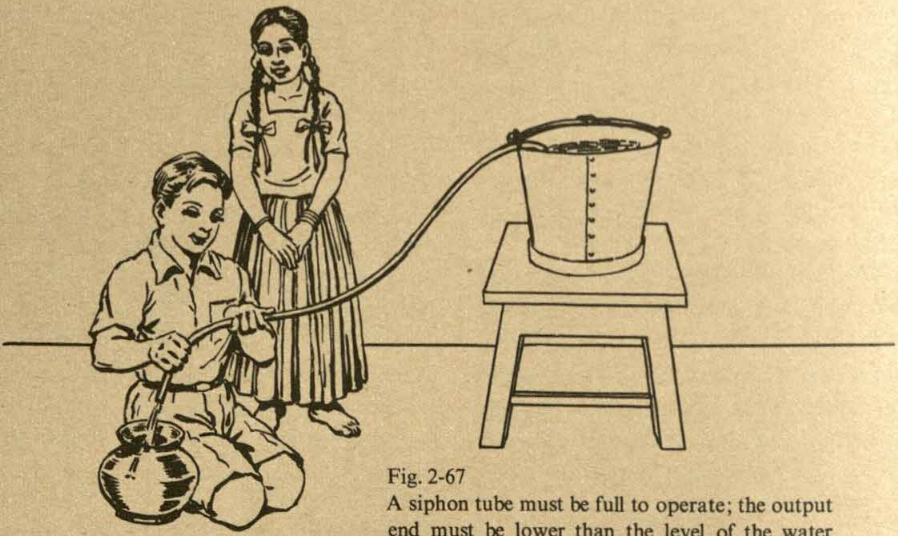


Fig. 2-67
A siphon tube must be full to operate; the output end must be lower than the level of the water supply.

**Discussion**

## How is a liquid forced through a siphon ?

Prepare a large sketch of a siphon similar to that in Fig. 2-68. Challenge students to say what they know about pressure at various points throughout the system. Guide their discussion so that they finally develop a line of reasoning, something as follows. This applies when the liquid is motionless, but it is almost true even when the siphon is operating.

The pressure at a is the the same as at A, since both are exposed to normal atmospheric pressure.

The pressure at b is the same as at B, since both are equally elevated above a and A.

The pressure at c is the same as at C, for reasons similar to above.

As one goes from a to b to c, and from A to B to C, the pressure becomes less and less, since one is going upward in a liquid.

Following this line of reasoning, it is seen that the pressure at C is greater than that at d.

When free to move, liquids move from regions of higher pressure to regions of lower pressure. Hence the siphon operates from C towards d—from right to left in the sketch.

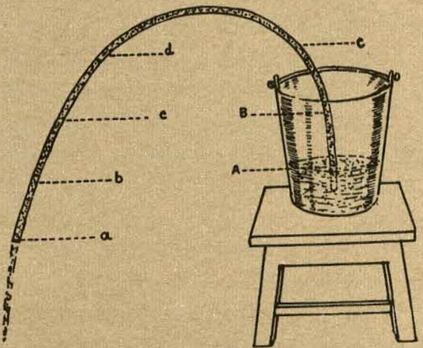


Fig. 2-68
The operation of a siphon can be analyzed in terms of differences of pressure inside the siphon.

*While a siphon is in operation, puncture a hole in the top bend of the tubing. Have students predict, then explain the result.*

*Call attention to the inverted siphon used when an irrigation ditch crosses under a road.*

**For Better Understanding**

All the devices mentioned under this major concept operate on the same basic principle. Normal air pressure pushes liquids towards a region where the pressure has somehow been reduced. The only difference among the devices is in the details of how the internal pressure is reduced.

This illustrates one of the important features of scientific analysis. One need not memorize how the drinking straw, the syringe, the lift pump, and the siphon operate. Instead, one should understand the underlying principle, and then apply it to various situations.

## 3. AIR CONTAINS MANY GASES USEFUL TO MAN

Air is not a simple gas, consisting of only one kind of material. Of course, it usually contains dust and pollen, but these are not gases. The gaseous part of the air contains several different substances of which four are important to man. Two of these four elements are—oxygen ($O_2$) and nitrogen ($N_2$). The other two are compounds —carbon dioxide ($CO_2$) and water vapour ($H_2O$). Several other gases are also present, but in quantities of 1% or less. Argon, which makes up about 1% of the atmosphere, is not very important to man.

In this major concept, it is not important that children should memorize these percentages. However, it is important that they realize that air is not a single gas. Also, they should learn general ways in which each of the four important gases is useful to man.

### 3(a). THE GASES—OXYGEN, NITROGEN, CARBON DIOXIDE, WATER VAPOUR AND ARGON ARE PRESENT IN AIR

Of the several gases present in air, four are of great use to man. These are:

$O_2$ —21% $N_2$ —78%
$CO_2$ —0.002%—0.004% $H_2O$—varies

The oxygen and nitrogen content of the air are almost constant under all conditions. In the open air carbon dioxide occurs only in very small quantities, but it is listed here because it is so very important, particularly for plant life. The air is never completely without water vapour. Depending on weather conditions, the air may have water vapour up to about 5% of the total gases present. Here is a way to help students appreciate the composition of air.

**Discussion**

**What is in the atmosphere?**

Students at this class level know about molecules. Ask them what the molecules of the air are like. An answer like 'an air molecule', of course, is incorrect. Now illustrate the contents of the air with a chart, showing the percentages by volume of oxygen, nitrogen, and carbon dioxide. Have students notice that everything else in the air (except water vapour) adds up to about one per cent. (This is almost entirely argon.) Challenge students to make all this into a drawing where gases of the air are represented by sectors of a circle. See Fig. 2-69.

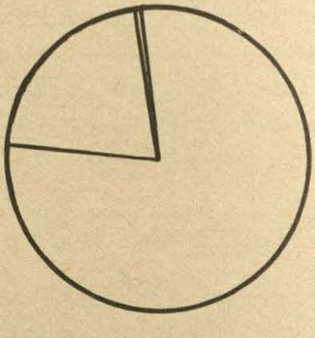


Fig. 2-69
Graphs of the gases in the air can make the concept more clear to students.

*Read about the work of Joseph Priestley, who did many early experiments with oxygen.*

## For Better Understanding

The other gases of the atmosphere have no importance to living things, although some have industrial and scientific uses. Argon makes up nearly one per cent of the air. Krypton, neon, and xenon are also present in very minute quantities. All the gases listed above are chemically inert—they almost never take part in a chemical reaction.

When making charts or graphs of the contents of the air, water vapour is not included. It varies a great deal from time to time. As it varies, it makes all the other percentages vary too, since they cannot total more than 100%.

### 3(b). OXYGEN IS USED WHEN FUEL BURNS

Of all the gases in the air, oxygen is by far the most important to man. Oxygen is a chemically active gas, and combines readily with many other elements. Ordinary burning is a combination of oxygen with fuel. Most common fuels contain hydrogen and carbon. Charcoal is nearly pure carbon. Students must be helped to realize that burning is not simply a matter of getting a fuel hot and changing it into smoke and ashes. On the contrary, it is a chemical reaction which involves the fuel and the oxygen of the atmosphere. Here is an activity which helps make this clear to the students.

**Investigation**

**Does a burning candle require something that is in the air?**

*Materials required*
clear glass jar,
candle,
match

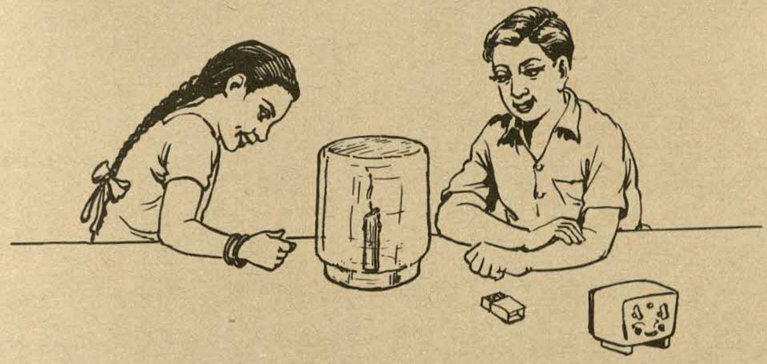


Fig. 2-70
Something in the air is required for a candle to burn.

Permit a student to set a small candle erect on the table. Light the candle. Now place a large glass jar upside-down over it, as shown in Fig. 2-70. With a watch see how long it takes for the candle to go out. Notice that it does not go out suddenly. Rather, the flame gets smaller and weaker until it finally goes out. Repeat with glass jars of other sizes. Note that the larger the jar, the longer the candle continues to burn. Guide the children to reason from this evidence that the candle flame depends for its existence on the presence of some material in the air. This material is the gaseous element, oxygen($O_2$).

**Scientists at Work**

### Lavoisier develops a modern theory of burning

Just about two centuries ago, scientists had a very definite idea about what happens when things burn. The idea sounds very unusual to us now, but at that time it represented the forefront of scientific thinking.

"When a fuel burns", said these scientists, "something is driven out of the fuel by the heat". That some thing disappears into the air. The material left after burning naturally weighs less than the original fuel. In this way fuel burns, produces smoke and hot air, and leaves behind a small quantity of ashes. The theory was very well established. There was even a special name for the material which was driven out of the fuel during burning. This was called 'phlogiston'. During the 1780's, a brilliant French scientist, named Antoine Lavoisier, became dissatisfied with the phlogiston theory. He developed new and better ways of weighing materials before and after burning. His wife helped him with his investigations. Together, they found that if you weigh the smoke, the water vapour, the carbon dioxide and the ashes, they weigh not less, but actually more than the original fuel. If the phlogiston theory were correct, then the all-important substance 'phlogiston' would have negative weight. The Lavoisiers could not accept such an idea; instead, they proposed a new theory of burning. They proposed that when a fuel burns, it does not lose any material. On the contrary, some new material is added to the fuel during the chemical reaction of burning. They called this substance 'vital air'. Today we call it 'oxygen.'

Lavoisier made a great step forward because he was dissatisfied with the existing explanation of what happened when things burn. He designed investigations to find a better explanation. This is what inquisitive scientists—and inquistive boys and girls—often do. This is an activity of science. Because of Lavoisier's great contribution to science, he is often called 'the father of modern chemistry'.

*Repeat the investigation in Fig.* 2-70. *Do two candles go out in half the time required for one candle to go out?*

*Smother a small fire with earth. Point out that the flame ceases because of the lack of oxygen.*

**For Better Understanding**

It is not true that a burning fuel consumes all the oxygen present in the air. Just how much is used depends on the nature of the fuel and of the flame. Materials like paper and wood and candles, however, consume perhaps one fifth to one third of the available oxygen before the flame is extinguished. That is, the flame can no longer continue when the oxygen content of the air falls to about 13% to 16%, as compared to the original 21%.

Most fuels contain the elements carbon (C) and hydrogen (H). Petroleum products consist almost entirely of these two elements, and are called *hydro-carbons*. Paper and wood and similar fuels contain other elements also. When a typical fuel burns, the hydrogen in it combines with the oxygen in the air to form water vapour. This can be represented by the chemical equation:

$$\text{H (in the fuel)} + O_2 = H_2O \text{ (water vapour)}$$

At the same time, the carbon in the fuel combines with oxygen to form carbon dioxide, according to this chemical equation:

$$\text{C (in the fuel)} + O_2 = CO_2 \text{ (carbon dioxide)}$$

The water vapour and the carbon dioxide so formed rise along with smoke and other materials from the flame. Ashes contain materials which did not combine with oxygen to form a gaseous product during burning.

**3(c).** ALL LIVING THINGS USE OXYGEN IN RESPIRATION

All animals, including man, are breathing almost constantly. Except for fish and some other marine life, animals breathe air. The lungs remove some of the oxygen from the air. This oxygen is then circulated by the blood to the cells of the animal's body, where it helps sustain life. In and around the cells, the blood also picks up carbon dioxide which has been produced by life processes. This carbon dioxide is then exhaled by the animal. Exhaled air contains less oxygen and more carbon dioxide than does normal air. Exhaled air is usually warmer and more moist than inhaled air. The activity which follows will help students realize that living things consume oxygen from the air.

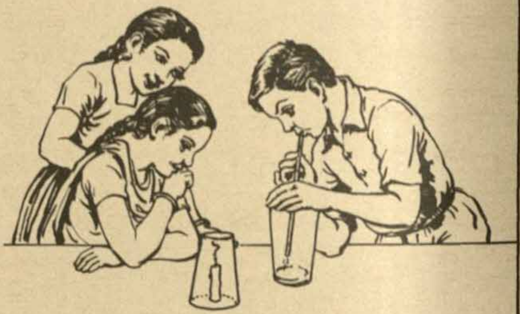
**Investigation**

**Do human beings remove oxygen from the air?**

*Materials required*
clear glass jar,
candle, match,
drinking straw,
watch

Recall the experiment with the candle under the glass jar in sub-concept 3(b). If this has not been carried out, do it now. Next, repeat the experiment. This time do not use a glass jar full of normal, fresh air. Instead, allow a student to fill the jar with exhaled air from his lungs. This can easily be done by having him blow air for a few minutes into the bottom of the jar through a drinking straw or other piece of tubing, as shown in Fig. 2-71. With a watch, measure the time required for the candle to be extinguished. Notice that it is considerably less than before. Help students reason from this evidence that the flame-supporting material in the air (oxygen) must be in short supply in the exhaled breath. That is, human beings use oxygen from the air.

Fig. 2-71
Exhaled breath does not support a candle flame.



*Discuss how oxygen is administered to people who are very ill.*

*Discuss the fact that mountain climbers and athletes sometimes use oxygen for extra strength and endurance.*

**For Better Understanding**

Respiration is the term given to the total process in which animals consume oxygen from the air, combine it with food material in their bodies, then release the carbon dioxide and water and other waste products back in the air. This internal reaction gives the animal energy for warmth and for motion, and also for other kinds of bodily activity. Plants similarly use oxygen from the air and food materials within their tissues for the process of respiration.

Animals do not consume all the oxygen from the air. Depending on the animal and the conditions of its breathing, it consumes perhaps one-eighth to one-fourth of the oxygen present in normal air. Notice that this is roughly the same oxygen consumption as with ordinary burning. The exhaled breath of animals contains more carbon dioxide than does normal air. With human beings. the $CO_2$ content of the exhaled air may be 3 or 4%, seldom more. The feeling of being 'out of breath' is from $CO_2$ in the lungs. A $CO_2$ content of 2% makes a person 'want' to empty his lungs and get a fresh breath of air. If the $CO_2$ content gets to 4% or more, the person is in real distress.

Fish and most other water animals extract oxygen which is dissolved in the water. The carbon dioxide which these animals produce during respiration is transferred from the fish into the water and literally dissolved in the water. Fish and many other marine animals accomplish this transfer of gases through the surfaces of special organs known as *gills*.

### 3(d). PLANTS AND ANIMALS USE OXYGEN AND RELEASE CARBON DIOXIDE IN RESPIRATION

The previous sub-concept has treated the use of oxygen during respiration by human beings and other animals. It is difficult to illustrate plants' use of oxygen during respiration at the elementary school level. However, the production of carbon dioxide during animal respiration is simple and interesting. Here is the general technique of detecting the presence of carbon dioxide.

**Investigation**

### Do animals exhale carbon dioxide?

*Materials required*
glass jar,
clear glass tumbler.
lime (slaked or unslaked),
drinking straw,
cycle pump

Carbon dioxide is readily detected with the aid of a simple chemical known as lime-water. Lime-water is really a solution of calcium hydroxide —$Ca(OH)_2$—in water. It is easily made in this way. Put a handful of slaked lime (quenched chuna)—$Ca(OH)_2$— into two litres of water and stir very thoroughly. Allow it to set for at least a day. Then carefully pour off the nearly clear liquid (decant it) from the sediment at the bottom of the jar. The portion poured off is lime-water. This can also be done with unslaked lime or quick-lime (unquenched chuna)—$CaO$. Care should be taken that the quick-lime does not burn the skin, particularly the eyes.

To see how lime-water indicates the presence of $CO_2$, permit a student to use a drinking straw or a piece of tubing to bubble some of his breath through a small glass of lime-water, as in Fig. 2-72. After a short while, the lime-water becomes cloudy, indicating the presence of carbon dioxide. Compare this with another sample of lime-water through which normal air has been bubbled with the aid of a cycle pump. After some lime-water has been used for a test, it should be discarded.

Lime-water can be used to show the

presence of carbon dioxide due to respiration in plants. Place a healthy potted plant under a larg glass jar, but with a small glass of lime-water inside the jar. This should be kept where the light is very dim. After a day or two, examine the lime-water. It will have a white scum across the surface, indicating the presence of $CO_2$. The plant must be kept in the dark in order to prevent photosynthesis from taking place. In the light, plants consume more $CO_2$ through photosynthesis than they produce through respiration.

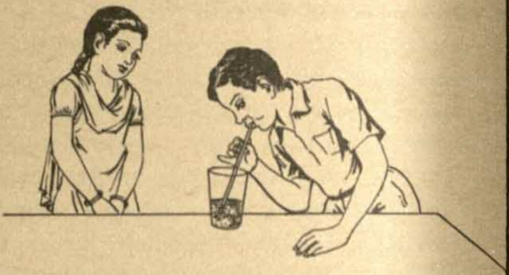


Fig. 2-72
Lime-water indicates that exhaled breath contains carbon dioxide.

*Burn a candle under a jar where a healthy green plant has been in the sunshine. Repeat with a similar plant which has been in the darkness. Which candle burns longer? Why?*

### 3(e). PLANTS USE CARBON DIOXIDE AND RELEASE OXYGEN WHILE PRODUCING FOOD

Students already know that plants manufacture food through the process of photosynthesis. In this process, the energy of sunlight is used to convert $CO_2$ (from the air) and $H_2O$ (from the soil) into food-materials. Oxygen ($O_2$) is produced as a by-product. Photosynthesis occurs only in the presence of chlorophyll, and hence only in green plants. The chemical equation for photosynthesis can be expressed like this:

$$CO_2 + H_2O \rightarrow C_6H_{12}O_6 + O_2$$

Here $C_6H_{12}O_6$ is a simple form of plant sugar. Other forms of food-material, such as starch, are also formed.

Although simple in concept, the chemistry of photo synthesis is really extremely complex. Much of it is beyond the level of effective experimentation at this class level. However, it is possible to show that plants give off oxygen during photosynthesis.

**Investigation**

**Do plants produce oxygen during photosynthesis?**

*Materials required*
green water plant,
clear glass jar,
water

Obtain a supply of a healthy, leafy plant which grows in fresh water. A common example of such a plant is hydrilla, found in many swamps and ponds. Observe this carefully as it grows in a glass jar in the classroom. After the plant has been in strong sunlight for an hour or so, tiny bubbles will be seen on the leaves. These are bubbles of oxygen. See Fig. 2-73.

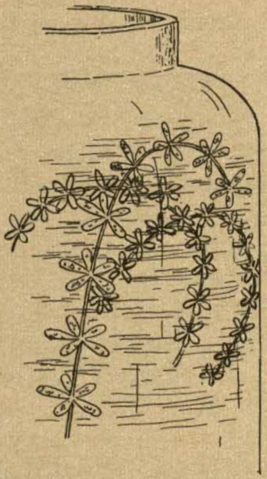


Fig. 2-73
Green water-plants produce tiny bubbles of oxygen during photosynthesis.

*Analyze the structure and meaning of the words 'photosynthesis' and 'chlorophyll'.*

*Try to prepare a balanced aquarium. Find out how to do it from a secondary school biology teacher.*

**For Better Understanding**

It should be emphasized that photosynthesis and respiration are reactions which are chemically opposite to each other. In photosynthesis, energy (from the sun) is consumed. In respiration, energy is released.

The two equations may be compared in this way:

photosynthesis: $CO_2 + H_2O$ + energy (from sunlight) $\rightarrow C_6H_{12}O_6 + O_2$

respiration: $C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$ + energy

It is very important that children be helped to see this. When they have this concept, they can see how plants make solar energy indirectly available to animals. They can see how human beings and other animals could not possibly live without plants. This is the most important concept in understanding the interrelationship between animals and plants and their physical surroundings, including the energy in sunlight.

Many of the ideas in this major concept involve simple chemistry. It is true that students have not yet had any formal training in chemistry according to this syllabus. This is a good place to introduce some of these ideas. However, there should be no emphasis on memorization of chemical symbols, formulas, or equations. The symbols can be used simply as convenient 'abbreviations'. If this is done, the 'abbreviations' should be the correct chemical symbols.

Many common elements, including oxygen, hydrogen, and nitrogen occur as gases. In the elemental form, these and some others are made up of molecules, each consisting of two atoms. For this reason, they are properly indicated not as H, O, and N, but as $H_2$, $O_2$, and $N_2$. In sub-concept 3(b), however, the chemical reaction involved is not the elemental gas hydrogen, but hydrogen in chemical combination with some fuel. In this case, it was indicated simply by H.

More advanced students of chemistry would not be satisfied with a reaction equation such as the one used here for photosynthesis and for respiration. The fault is that the number of atoms of each element are not the same on both sides of the equation. For example, the left side of the photosynthesis equation has one atom of carbon, two of hydrogen, and three of oxygen. The right side, however, has six atoms of carbon, twelve of hydrogen, and eight of oxygen. It is possible to 'balance' such an equation and make it more meaningful (and correct). However, the balancing of chemical equations can be ignored at this class level. Indeed, no great harm will be done if oxygen, nitrogen, and hydrogen are represented simply by O, N, and H.

The importance of water vapour in the air has been considered earlier in this handbook. Nitrogen from the atmosphere is not directly used by plants and animals. However, certain bacteria growing on some plants are able to extract nitrogen from the air and make it available to plants. Through the plants, it also becomes available to human beings and other animals. These bacteria are known as *nitrogen-fixing bacteria*. The plants on which they grow include all the pulses, other legumes like beans and peas. The air is also an important source of nitrogen for the chemical industry.

## 4. WATER IS A GOOD SOLVENT

This major concept has already been given some attention in class IV. It is useful to refresh the students' minds on the matter and carry the concept even further here in class V.

### 4(a). WATER DISSOLVES MANY THINGS

Children and adults know well that water is the most common liquid. But they often fail to realize that it is a better solvent than any other familiar liquid. It dissolves more substances than such liquids as petrol or alcohol (spirits). Children already know that water dissolves such solids as salt or sugar. Here are activities which will help the students towards an improved understanding of this sub-concept.

**Investigation**

**Is water a superior solvent?**

*Materials required*
four clear glass jars,
kerosene, alcohol, cooking
oil, trial solubility materials

Challenge students to see which common materials are soluble in water and which are soluble in other liquids. This is simply a matter of experimenting. They should attempt to dissolve in water such materials as salt, sugar, metals, plastic, flour, quenched chuna (slaked lime), chalk, soda, alum, epsom salts, borax, copper sulphate, ammonium chloride and washing soda. Then, they try to dissolve the same materials in kerosene, alcohol, and cooking oil. These investigations can be carried on either at school or at home. Ask students to report *on the basis of their own evidence* which liquid is the best solvent.

*Experiment to see to what extent sugar or alum is more soluble in hot water than in cold water.*

**For Better Understanding**

Actually, it is incorrect to think of materials as being either 'soluble' or 'insoluble'. Nearly all substances are at least slightly soluble in water, even substances like glass and stone and oil. That is, solubility is not a matter of 'yes or no' but a matter of 'how soluble'. Liquids and gases can be dissolved in water, just as solids.

For most materials, hot water is a better solvent than cold water. For some materials, such as sugar, the difference in dissolving ability varies greatly with temperature. Common salt is an exception; the temperature of the water makes almost no difference in its solubility.

**4(b).** DISSOLVED SUBSTANCES CAN BE SEPARATED FROM WATER BY EVAPORATION

It is frequently desirable to separate water from a material dissolved in it. For example, the sweet juice of sugar-cane is a solution of sugar in water. To get syrup, or jaggery, it is necessary to get rid of most of the water. One way to do this is by evaporation. Under proper conditions, most or all of the water can be evaporated away leaving syrup or solid sugar. In a similar way, controlled evaporation can be used to separate water from many other materials dissolved in it. Here is an activity which will provide students with first-hand information concerning this sub-concept.

**Investigation**

**How can dissolved materials be separated from water?**

***Materials required***
salt or alum,
water,
clear glass jar

Dissolve some salt or alum or washing soda in water. Permit a student to taste it to indicate that it is really there, even though the solution may be colourless. Challenge students to get the original solid material back again, much as it was in the original container. Some may suggest filtering (which was taken up in class IV). Permit a student to try to filter a dissolved material from a solution. Of course, he will fail. Also try any other techniques suggested by the students. Among others, try evaporation. If the solution is set in a shallow pan on a warm, dry day, the liquid may all evaporate before the day is over. If the solution is gently heated, evaporation will be hastened. When the solid residue remains, taste it to see if it is like the original substance.

*Permit a few drops of drinking water to evaporate from a* very clean *glass dish. Any smudge left after the water is gone is from materials dissolved in the water.*

*Repeat the above with the purest water that can be found and then with rain water.*

**4(c).** DISSOLVED SUBSTANCES CAN BE SEPARATED FROM WATER BY DISTILLATION

In the separation of water from a dissolved substance, as discussed above, the water was converted into water vapour and permitted to escape. Sometimes, however, it is desirable to collect the water. This is done in the process of *distillation*. In distillation, controlled heat is used to boil the solution, and the water vapour leaves the solution through a pipe or a tube. The water vapour or steam is led to a cool place where it condenses back into water once more. In this process, pure distilled water is obtained, while the impurities in the solution being boiled become more and more concentrated. Here is a way to set up a simple distillation apparatus for use in the classroom.

**Investigation**

**How is distillation carried out?**

*Materials required*
heat resistant glass flask, one-hole stopper, short straight glass or metal tubing, flexible tubing, slender clear bottle or test tube, clear glass jar, copper sulphate, cold water, source of heat

Arrange containers and tubing in the manner of Fig. 2-74. Ideally, all the containers should be of glass. In the boiling flask, use a solution of copper sulphate and water, a strong enough solution to be distinctly blue. The steam which passes through the delivery tube will be colourless, since only the water, not the copper sulphate, has evaporated. As the steam enters the bottle it condenses. The bottle is kept cool by being immersed in cold water. Note that the recondensed—distilled—water is colourless. It has been separated from the copper sulphate dissolved in it.

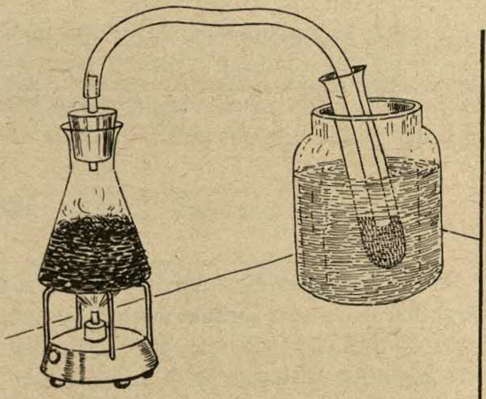


Fig. 2-74
When dissolved materials are separated from a liquid by distillation, both the materials and the liquid are saved.

*Read about how distillation is used to separate alcohol from a weak solution of alcohol in water.*

*Read about how petroleum is refined using the process of 'fractional distillation'.*

**For Better Understanding**

Distillation may be thought of as a special case of rapid evaporation. It is 'special' in that the liquid is saved, not allowed to drift away into the air as water vapour. Distillation is used when it is desired to preserve liquid. This is the case when pure water is needed for chemical laboratories, or for use in the accumulator of an automobile. Sometimes distillation is used to separate two liquids. Alcohol is separated from water in this way. Alcohol has a lower boiling point than water. So a mixture of the two is heated to a temperature where the alcohol evaporates well but the water evaporates more slowly. Then alcohol vapour comes out of the heated vessel and is condensed in a cool condenser. In a similar way, various liquids present in petroleum are separated to provide such products as petrol, kerosene, lubricating oil, and paraffin.

Evaporation is commonly used when one does not desire water, but wants in a concentrated form the material in water. Thus syrup and sugar are obtained from cane-juice by evaporation. Milk is commonly concentrated by evaporation for use in sweets and cheese and other milk products. The process is the same, even though much of the residue left was not actually dissolved in water in the original milk. (Much of the material which makes up milk is not dissolved, but suspended in water as tiny insoluble particles).

## 5. WATER MAY CONTAIN INSOLUBLE SUBSTANCES AND GERMS

Students at this class level have already seen that water can contain many materials, both soluble and insoluble. They know that the insoluble materials may be sediments. Given sufficient time, these usually settle down (sedimentation). But some insoluble materials are so finely divided that they do not settle. This results in a *suspension* (or colloidal suspension) of the materials in water. Some inks and some foodstuffs are suspensions. Milk and chocolate drink are good examples of liquids which have a great deal of insoluble material suspended in them.

Another important kind of insoluble material in water is made up of micro-organisms—tiny living things. These include bacteria and virus germs. These kinds of impurities are particularly important because of their effects on human health. In this major concept, emphasis will be placed on removing from water harmful insoluble materials, including germs.

### 5(a). INSOLUBLE MATERIALS CAN BE REMOVED BY SEDIMENTATION AND BY FILTRATION

In earlier classes, students have already had contact with the ways of separating insoluble materials from water. Among these ways have been sedimentation and filtration. In this present sub-concept, the emphasis is on the use of such methods for water purification. The general idea of water purification by sedimentation and filtration can be made more clear through activities such as these:

**Investigation**

**Does sedimentaion help purify water for drinking?**

*Materials required*
clear glass jar,
dirty water

Stir a handful of dirt into a glass jar nearly full of water. Allow the mixture to settle long enough so that the students can see that sedimentation has occurred. In most cases, the water will still be cloudy even after an hour or so. Allow the mixture to settle for a few days. Ask children if they have separated the water from the insoluble dirt. Next, ask if they have also separated through this sedimentation all the in-insoluble material. (Not necessarily—there may be dirt so fine that it cannot be seen still suspended in the clear water.)

**Investigation**

**Does filtration help purify water for drinking?**

*Materials required*
two clear glass jars,
cloth, dirty water

Set up a simple filter to separate the dirt from some muddy water. For this purpose, filtering can be done simply by pouring through several layers of fine-woven cloth. Ask students if they have succeeded in filtering the visible dirt from the water. Is it possible that they have not succeeded in filtering out all the dirt? (Yes, it is possible—some dirt may be so fine that it goes through the filter.)

*Experiment with different kinds of cloth and paper to see which makes the best filter.*

*Experiment to see which (filtration or sedimentation) makes the water cleaner.*

**For Better Understanding**

Not all filters are similar. Some very coarse filters will only filter out large pebbles from a muddy mixture. A finer filter may filter out grains of sand, but let muddy clay-like material go through. In a similar way, it is possible to have a filter which removes visible dirt, but allows extremely fine particles to go through. One cannot be sure that he has really purified water by sedimentation or by filtering unless he has a positive way to test the safety of the water that passes through the filter.

**5(b).** DISEASE-CAUSING GERMS MUST BE KEPT OUT OF WATER BY SANITARY MEASURES.

Because germs in water can be so very harmful to man, some ways must be found either to keep the germs out, or to remove them once they are there. This is a problem which faces not only water supply engineers in large cities, but also individual families in towns and villages everywhere. Depending on the conditions, there are several ways in which this can be accomplished.

Careful people everywhere use many means of keeping water clean for drinking purposes. They keep animals and insects out of drinking water. They keep water supplies covered to keep the dirt out. They wash out tumblers before they drink water from them. Here is a kind of activity which will help draw the children's attention to the problems of keeping water clean.

**Discussion**

**What ways do we use to keep water clean?**

Ask each student to list five ways in which water, once clean, is kept clean. They may draw either from their own experience at home or from what they have heard or read. Now ask them to think critically about these procedures.

Are they really effective? Remind them that they cannot see or smell germs. Ask them whether or not merely rinsing a glass with cold water is a sure method of cleaning it. Finally, ask them to revise their list so as to have five ways of keeping water clean which are really effective.

*Invite a district health officer to speak to the class.*

*Read about such topics as communicable diseases, public health and sanitation.*

**5(c).** NOT ALL GERMS CAN BE REMOVED FROM WATER BY SEDIMENTATION AND FILTRATION

This is closely related to the idea in sub-concept 5(a) of this unit. Here, however, the emphasis is on germs rather than on inorganic impurities. Activities like these can help students understand this extension to the ideas about sedimentation and filtration.

**Investigation**

**Do some germs remain after water has been settled or filtered?**

*Materials required*
gravel, sand, mud mixture, two clear glass jars, water, screen wire or coarse cloth for filter, fine cloth for filter

Stir a handful of gravel, sand and mud into a glass vessel nearly full of water. Challenge students to separate the dirt from the water. Some, of course, will want to filter it. Begin by filtering it through screen wire or through very coarse cloth. Only pebbles and some sand will be removed. Students will now want to use a finer filter. Use a few layers of moderately fine cloth. More, but still not all of the visible dirt will be removed. Now use a still finer filter—one made from paper towelling or something similar. With care, nearly all the visible dirt can now be removed. But remind the students that the earlier filters in this activity did allow very finely divided materials to pass through. Perhaps there are still more finely divided materials which go through this very fine filter. Perhaps the particles are too small to be seen. Perhaps they are germs. Help students realize that these methods of purifying water are not always safe, even though they may leave the water crystal clear.

*Encourage students to find out what they can about germs from a local doctor or nurse. In particular, how big are these organisms?*

*Look up the term 'virus'. Find out what is meant by 'filterable virus'.*

**5(d).** MOST GERMS CAN BE KILLED BY PROLONGED BOILING, OR BY CERTAIN CHEMICALS

Most germs can be effectively destroyed by prolonged heating. Usually, a vigorous boiling for 20 minutes will be sufficient. In large cities, the drinking water supply is sometimes purified by the addition of certain chemicals—such as chlorine in very small amounts. This keeps the presence of germs low enough to be safe without otherwise harming the water. Sometimes such water has an unusual taste. But the water is safe for drinking, safer than if no chemicals are added. Students can be helped to understand this treatment of water through an activity such as this.

**Interview**

**To what extent is water purified by boiling?**

Ask Children to find out in their family and in their community to what extent water is boiled before being used for drinking. In most places some boiling is done, depending on the source of the water or on the time of the year. Perhaps children will know of some people—Indians or foreigners—who always boil water before drinking it. Ask them what is done to milk before it is used for food. Perhaps they can find foods which are boiled or cooked (to destroy germs) before being eaten.

*Have children find out from their parents what happens if they use milk which has not been boiled.*

*Ask district dairy officer to speak to the class about pasteurization and other methods of making milk safe for use.*

## For Better Understanding

An increasing number of informed people are becoming more and more conscious of the danger in their water supply. Even in large cities, water is sometimes made safe by boiling at certain times of the year. Foreign visitors often insist on drinking nothing but boiled water. They may even ask that water be boiled before it is made into ice cubes for ice water! Travellers must be particularly careful because they may not be accustomed to certain mild germs to which local residents have become accustomed and largely immune. A similar thing happens to local people when they travel abroad, or even in far parts of India. Slightly impure water which may not affect local users at all may make travellers very ill. Young people should learn not to be insulted when a visitor asks for boiled water, and should try to understand his desires.

Throughout this concept, the big idea is that germs are not only dangerous, but are also invisible. Children must be taught that water which merely *appears* to be clean may not be safe for drinking at all. Teachers can do a great deal for children and their communities if they make them more and more alert to the possibility of impure water, and to the ineffective ways in which many people try to keep their water supply safe.

## 6. WATER EXERTS PRESSURE

Already in class V, children have been exposed to the basic notion of air pressure. (See basic concept 1 of this unit). They know that pressure is closely related to force. They have had a first exposure to the notion that pressure is force per unit area. They also know that air exerts pressure because of the bombardment of molecules in the gas. They know that normal atmospheric air exerts a pressure of nearly one kilogram of force per square centimetre. In this present major concept, children can expand their learning about pressure to include water pressure. They can learn what causes water pressure, and how it is affected by depth.

### 6(a). WATER PRESSURE VARIES WITH DEPTH

Any object which is under water has force exerted on it. This force is due to the weight of the water above the object. The force applied to a given area is the pressure of the water there. Imagine, for example, a column of water 25 cm high and one square cm in cross-section. This contains 25cc (25 cubic centimetres) of water, which has a weight equal to 25 grammes of force (25 gf). Therefore the total force on the 1 square centimetre of area at the bottom of the column is 25 gf; this is the weight of the water directly above the one square-centimetre area. The pressure is force per unit area, or 25 gf per $cm^2$. From this it is seen that the pressure produced by water (or any other fluid) at any point depends on the depth of that point. Here is a simple activity which can help make this point clear to the students.

**Investigation**

## How does water pressure vary with depth?

*Materials required*
rubber balloon,
water,
pipe or tubing,
string or rubber band

Obtain a small rubber balloon. It should be stretched by inflating it a few times, so that it will not be too 'strong'. In this activity, the balloon will be inflated with water. The water in the balloon will be under pressure due to the weight of water above the balloon.

With a string or a rubber band, tie the balloon to the bottom of a piece of glass tubing, or rubber tubing, or even a piece of pipe. The balloon has collapsed and is empty. Now pour water into the tubing, as shown in Fig. 2-75. At first the water flows into the balloon but does not inflate it very much. The balloon is too 'strong'. Eventually, the balloon begins to inflate with water. Help students realize that as the depth of water above the balloon increases, the pressure at the level of the balloon also increases. Finally, the pressure becomes enough to overcome the 'strength' of the balloon, and inflation begins.

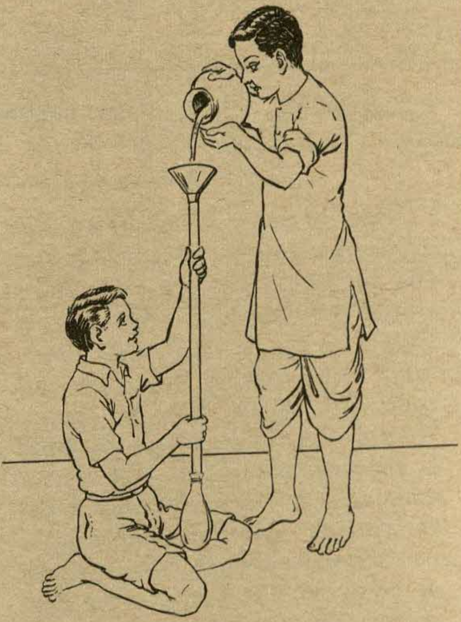


Fig. 2-75
Increasing depth of water produces more force to push water into the balloon.

*Discuss with students why a dam is thicker at the bottom than at the top.*

*Read about submarines and about deep-sea diving. How is the great pressure of the water withstood?*

### 6(b). WATER EXERTS PRESSURE EQUALLY IN ALL DIRECTIONS

It is easy to see why at any point there should be force and pressure downward under water. This is due to the weight (which is a force) of the water above the point. It is difficult but very important to realize that pressure is exerted not only downwards, but also sideways and upwards. Indeed, at a given point the pressure is the same in *all* directions. This is true regardless of what has produced the pressure. Here are activities which can help the students grasp this concept.

**Investigation**

**In what direction is underwater pressure exerted?**

*Materials required*
tall tin can,
nail (to punch hole),
water

Obtain an empty tin can some 15-20 centimetres deep. Punch a hole in the side, as suggested in Fig. 2-76. Have a child cover the hole with his finger while the can is filled with water. When he removes his finger, the water spurts out of the hole, as shown. Students can easily see that the water is spurting *outward.* It only curves down (due to its weight) *after* it has left the can. Ask students to explain why the water comes out horizontally or nearly so. The logical explanation is that it is forced out by a force—a pressure—which acts sideways.

If several holes are punched in the can, children can now observe that water comes out more forcefully from the lower holes. Help them see that this is because of greater pressure in the deeper parts of the can. This further illustrates sub-concept 6(a) above.

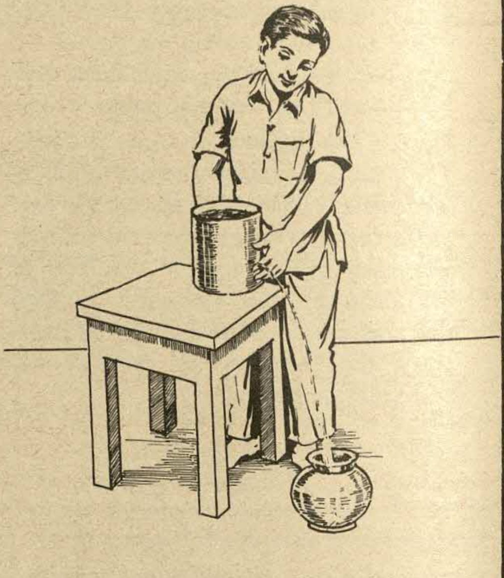


Fig. 2-76
Pressure within water is exerted sideways.

**Investigation**

**Is underwater pressure exerted upwards?**

*Materials required*
tall tin can,
nail (to punch hole),
water

Place a deep dent near the bottom of one side of the can, as shown in Fig. 2-77. Now punch a hole in the dent so that the hole is facing partially upwards. Have one student cover the hole with a finger while another student fills the can with water. Challenge the class to predict which way the water will spurt out when the hole is opened. Now check the proposed answers (hypothesis) by experiment. The water will be seen spurting out partially upwards. Help students infer from this that water pressure is exerted not only sideways, but upwards as well.

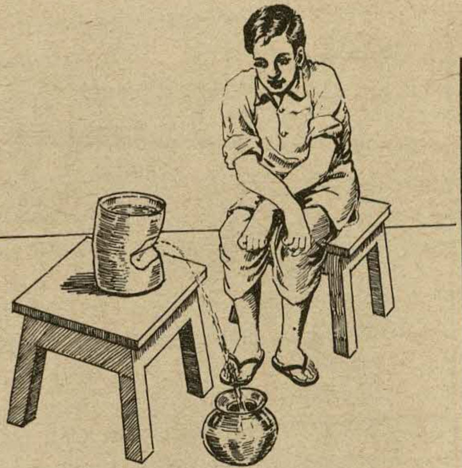


Fig. 2-77
Pressure within water is exerted upwards.

*Read about the French scientist Pascal who observed that fluid pressure at any point is exerted equally in all directions.*

*Ask students to tell how a submarine should be constructed if water pressure were downward only. Compare this with the actual construction of a submarine.*

**6(c).** WATER FLOWS FROM HIGH LEVEL TO LOW LEVEL

Every child knows that water runs down hills. This is because of the weight of the water; weight is a force which acts downwards. Because of weight, objects which are free to move do so in a manner which brings them closer to the centre of the earth. This concept of water flow can be nicely connected with the ideas of water pressure in this major concept. Here is an interesting activity which helps children see the idea of water flowing from high to low places in terms of water pressure.

**Investigation**

### Can gravity make water move upward?

*Materials required*
flexible tubing,
water

Obtain a piece of flexible tubing about a metre in length. Cover one end with a finger or thumb and fill the tubing with water. With the end still closed, bend the tubing into a shape like that in Fig. 2-78. Ask the students to predict what will happen when the lower end is opened. They will predict—correctly—that the water will come out of the lower end. Help them realize that water moves in the tube—if it can— from a region of high pressure to one of lower pressure. The pressure at point A is greater than that at point B because A is at a greater depth than B.

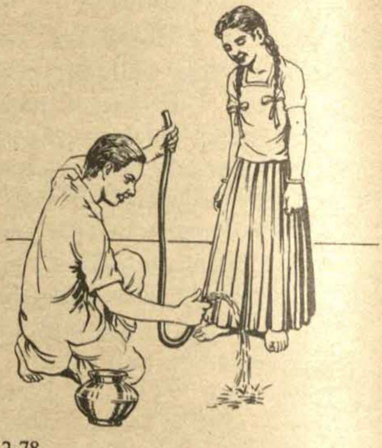


Fig. 2-78
Water flows from high level to low level.

*Ask students to explain a siphon's operation in terms of this sub-concept. Challenge them to demonstrate that liquids other than water also flow from high level to low level.*

*Ask students to explain and demonstrate the common statement 'water seeks its own level'.*

**For Better Understanding**

Pressure under water can be due to many causes. In the activities suggested above, pressure at a point has been related to the weight of the water above the point. But the surface of water is also subjected to atmospheric pressure. This is typically just over one kilogram of force per square centimetre (1000 gf/cm$^2$). Therefore, the total pressure at a water depth of, say, 3 metres (300 cm) would be 1300 gf/cm$^2$ (1000 plus 300). Eleven metres under water, the pressure is about 1000 gf/cm$^2$ due to the water only. The total pressure is about 2000 gf/cm$^2$. Even at lesser depths the pressure on a typical swimmer's ears is great enough to be painful.

Pressure can also be produced by applying force to a close-fitting piston in a closed container. Or it can be produced by simply squeezing a flexible container, such as a rubber balloon filled with water. Children can readily suggest experiments with balloons and water which illustrate useful concepts about the direction of pressure in water.

# UNIT 3

# ROCKS, SOILS AND MINERALS

## CLASS II

### Overview

This unit starts at class II level with the major concept, 'There are many kinds of rocks.' At this level, the aim is only to develop the interest of children in the study of rocks. This is done by pointing out to them the great variety of rocks present.

It is not enough to know that rocks are different from one another. The tremendous variety may simply overwhelm or confuse a child. The teacher can help children to observe the various ways in which rocks differ from one another. They may differ in size and shape. They may differ in their colours. They may differ in being soft or hard, sharp or smooth, and so on. This forms the subject-matter of three sub-concepts discussed under the one major concept of this unit. In spite of this great variety, many kinds of rocks can be grouped together. This is the one big theme discussed at this class level. Though this is the basic principle under any system of classification, the children at this class level are too young to comprehend it completely.

The big idea of 'pattern in diversity' is a very complex concept. Class II children can only make a beginning at understanding it.

### 1. THERE ARE MANY KINDS OF ROCKS

Small children often assume that 'rocks are rocks', and fail to notice what a tremendous variety of rocks there is. Geologists, of course, classify rocks and minerals according to precise and complex schemes. It is not the purpose of science instruction for class II students to undertake geological classification and identification. Rather, the teacher should help children to realize that there is a great variety in rocks, and that this variety shows itself along several lines, such as size and shape, colour, hardness, structure and other physical properties.

**1(a).** ROCKS OCCUR IN MANY SIZES AND SHAPES

The physical size and shape of rocks is one kind of variety. Some are large, some are small. Some are very smooth, while others have sharp edges. Some are simple pebbles, while others have complex and interesting shapes. Some rocks are loose—separated from the bedrock or the earth—while others seem to be an integral part of the earth itself.

It is possible simply to tell children of this variety in rocks. However, it is better science education to help them arrive at this concept through their own observations. Some activities through which this can be done are given below.

**Field Observation**

### How do rocks vary in size and shape?

Take children out on a trip to some hilly area or some other place where a good variety of rocks and stones may be found. If this is not possible, arrange to show pictures of such places to students. Children should be able to observe that rocks occur in many sizes and shapes. They may be helped to note that sharp edges are absent in many exposed parts of rocks.

**Investigation**

### How do our rock samples differ?

*Materials required*
samples of rocks

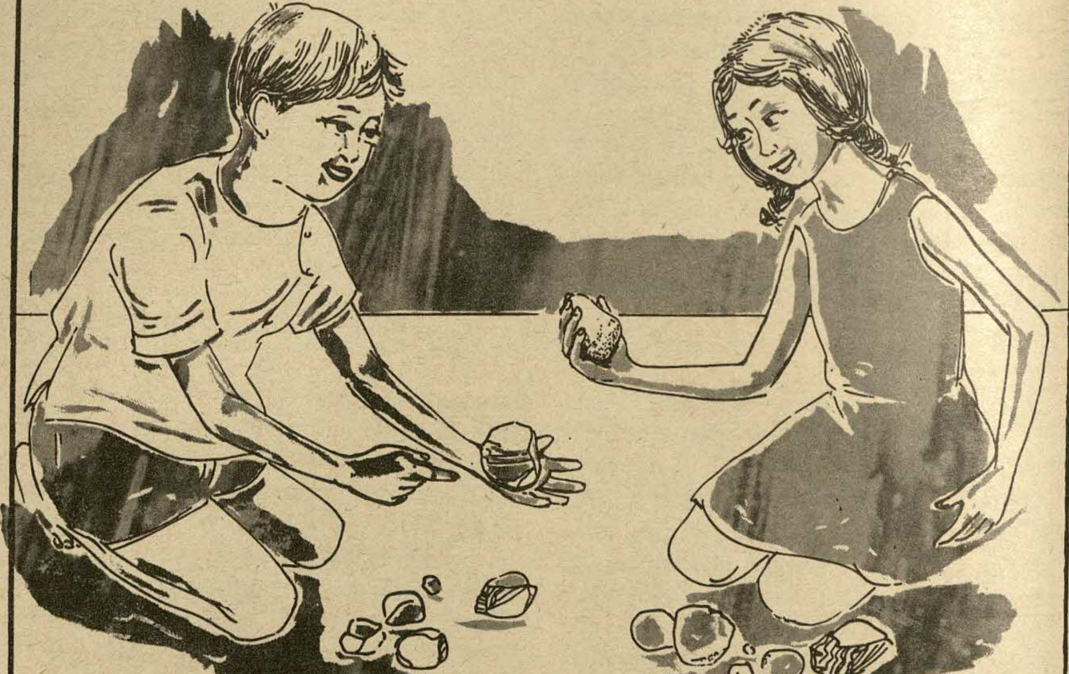


Fig. 3-1
Through their own observation, children find variety in stones.

Ask children to bring samples of rocks and stones to class. Have them show their findings to the rest of the class. Urge them to look for the smoothest stone, the most well-rounded stone, the largest or the smallest stone. Challenge them to find stones with unusual shapes. (See Fig. 3-1).

*Ask children to describe the sizes and shapes of rocks or stones used in their homes as household articles, such as* chakla-belan, sil-batta, *pestle-mortar,* pathrauta, *and grinding stone.*

### 1(b). ROCKS OCCUR IN MANY COLOURS

Another form of variety which rocks exhibit is that of colour. Often the colour is of minor significance to a geologist. However, colour makes rocks beautiful and interesting. Thus, the Red Fort at Delhi is built of red sandstone, and the Taj Mahal at Agra of white marble. These and many other structures are richly inlaid with designs of stone in many colours. Students can be helped to develop this concept of variety-in-colour through selected activities.

**Investigation**

**How do our rock samples differ in colour?**

*Materials required*
samples of rocks

Challenge children to find and to bring to class rocks of as many colours as possible. Help them to observe that while some rocks are of one colour, others have a variety of colours. Encourage children to make coloured pictures of the most attractive rocks they have found. The teacher should collect some of the most interesting samples to show to future classes.

*Ask children to draw coloured sketches of household articles made of white, black, red or green stone. Some examples are* chakla *(white or red), pastle-mortar (black or dark green), and* sil-batta *(red sandstone).*

### 1(c). ROCKS DIFFER; SOME ARE SOFT, SOME ARE HARD, SOME ARE SHARP, ETC.

Children are most apt to notice the variety that rocks display in size, shape, and colour. However, other kinds of variety are of much greater interest to the geologist or the stone worker or the designer of buildings. These kinds of variety are mostly in terms of some properties of rocks, e.g. their hardness, their internal structure, and (for later classes) their chemical composition. Good science teaching requires that children should be helped to arrive at these conclusions on the basis of their own first-hand observations, not that they merely be told of this variety. Some first-hand experiences of this type can be had through these activities:

**Investigation**

**Do rocks differ in their hardness?**

*Materials required*
samples of rocks

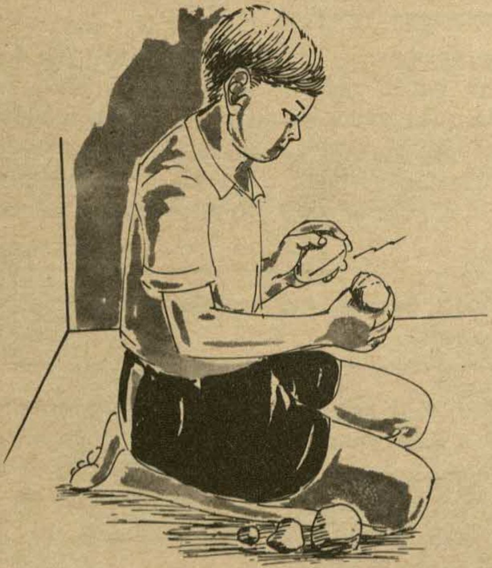


Fig. 3-2
Children can compare the hardness of two rocks by scratching them on each other.

Choose any two rock samples. Ask a child to scratch one with the other. The one that scratches is harder than the one that is scratched. The child may be asked to arrange his rock samples in order of their hardness by applying the above test. (See Fig. 3-2). The students may follow this activity individually.

*Divide the entire class into four groups and have them compete for finding out the hardest rock sample.*

The following activity will help children to appreciate that while some rocks are built of layers cemented together, others are not of this type.

**Investigation**

**How does shale differ from granite?**

*Materials required*
samples of shale
and granite

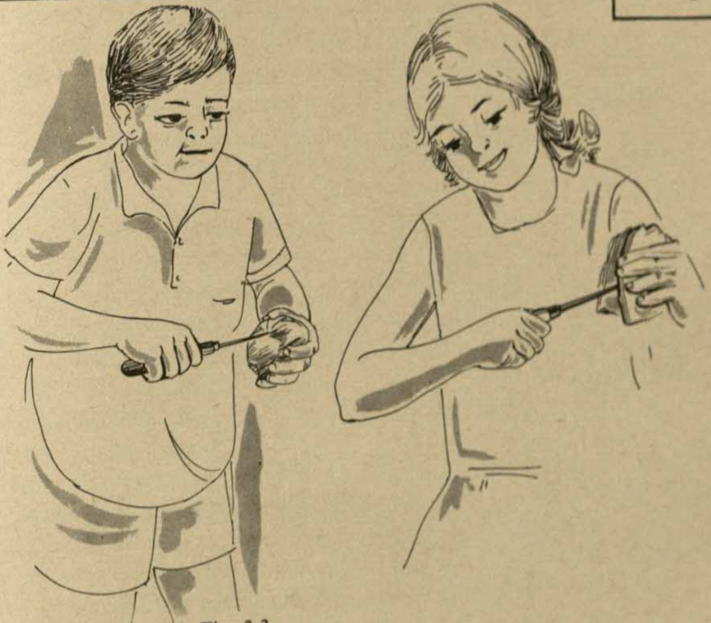


Fig. 3-3
Granite is a hard material; shale can be easily split into layers.

Invite children to examine a piece of shale and granite, and see if both of them can be separated into layers. (See Fig. 3-3). They will find that while shale can be separated in this way, granite cannot be, because it does not have a layered structure.

*Discuss with children the question: "Which is harder—the slate or the piece of chalk with which they write?"*

Similarly, children should be helped to observe through activities that rocks of almost similar size may differ appreciably in weight (e.g. granite is heavier than pumice). While some rocks have sharp edges, others are smooth (e.g. obsidian).

**Scientists at Work**

## Primitive man sometimes behaved like a scientist

Man is civilized, while animals are not. When man started on this lonely path, leaving all other animals behind, no one can accurately tell. Nevertheless, we can imagine the important steps in which this path of progress has been carved by man.

Discovery of the use of rocks for preparing stone implements is one such important step. Let us see how this invention of ancient times compares with the discoveries and inventions of modern scientists.

Like scientists, ordinary people also observe and reason. This was as much true thousands of years back as it is today. Early man observed that he was hurt when he fell upon a pointed rock. Perhaps he saw the relation between a hard fall against the stone and the resulting injuries. This is just what most people do even today—observing and noting cause-effect relationships. Then some intelligent and imaginative person used this cause-effect relationship in a new situation. This time he did not plan to fall on a pointed rock and injure himself. Instead, he planned to strike a wild animal by hurling a pointed stone at it. The scheme worked. The animal was hurt. Perhaps in this way the use of stone weapons began.

Again, man in very early days knew only about natural fires—as from lightning. He searched for these natural fires and maintained them for his own use. But he was not able to *make* a fire. Then, perhaps, some active playful person observed that a spark was produced by striking two stone pieces against each other. He experimented with the spark. He observed that the spark could set fire to dried leaves and pieces of wood. Thus man invented a way to produce a fire.

Besides making implements and producing fire, stones were used by early man for many more things. Making a fireplace out of stones was probably one of these. Not all stones, however, served this purpose equally well. Some simply cracked and crumbled in contact with fire. Through trial and error, man learned to select stones for specific purposes. Some kinds were good for implements, others for producing a fire, and still others for making a fireplace. All this selection demanded careful observation.

Thus, man has been observant from very early times. He has been curious and has experimented with things of his environment. That way he has learnt to use the surroundings for his benefit. These three uses of stones—making of implements, fire, and fireplace are examples of man's capacity for experimentation, observation and reasoning. This is what thinking people—scientists and non-scientists—do even today to develop new ideas.

## For Better Understanding

Some children and their teachers are confused about the similarity between the terms 'rock', 'stone', and 'mineral'. Between 'rock' and 'stone' there is little difference. Geologists seldom use the term 'stone', although this word is often used by builders; it is also commonly used to describe a rock that is small enough to be carried in the hands. In general, every 'stone' is a 'rock', but not every 'rock' is a 'stone'. The term 'mineral', on the other hand, is used to describe a specific fragment of rock-like material, but one which has a uniform chemical composition. Some precious stones, such as diamond and topaz, are minerals; so are materials like quartz, mica and graphite. Common salt is also a mineral. Most ordinary rocks however are made up of two or more minerals; thus one kind of granite (a rock) is made up of these minerals: quartz, feldspar, and mica. Marble is a rock made up almost entirely of the mineral calcite.

Children often fail to see the relationship between loose rocks which they find on the surface of the earth and the solid rock which underlies soil and gravel. They can be helped to see this relationship if a place can be found where the earth's crust—often called *bed-rock*—comes to the surface. Children may be helped to realize that rocks and stones are, in general, fragments which have broken away from bedrock. They have been broken up (weathered) by many different processes and they have been more or less smoothed off (eroded). These processes are often carried on by running water, sometimes by wind-blown sand, sometimes by the grinding action of ice in glaciers.

There should be no attempt at formal classification of rocks at this class level. Names used should be only common names of rocks. Even so, the existence of variety does invite some kind of classification. Children may be asked to arrange rocks in some pleasing pattern—perhaps by colour, or by size or by shape. Any system of arrangement is satisfactory; whatever it is, it shows the principles of classification.

INSTITUTE OF EDUCATION FOR WOMEN * CALCUTTA-27 *
Dept. of Extension
SERVICE

# UNIT 3

# ROCKS, SOILS AND MINERALS

## CLASS III

### Overview

Children have seen for themselves at class II level that rocks show a great variety. They are also familiar with many uses of rocks in their daily lives. The tremendous importance of rocks in producing soil is however something that children cannot find out by themselves. They must be helped to discover it. In this unit at class III level teachers should try to develop among children this understanding of rocks and soils.

In the first major concept of this unit, children notice for themselves that like rocks, soils also display a great variety. They may vary in the size and colour of their particles. They may vary in the content of organic matter. These variations exhibit a pattern in such a way that soils may be classified as clay, loam or sand. Children are here encouraged to make observations and collect information about soils. They are also helped to organize this information.

The second major concept 'different kinds of soils are formed by disintegration and by movement' deals with the relation between rocks and soils. One sub-concept gives children an understanding of how rocks are broken down into soil by expansion and contraction due to changes in temperature. The other discusses the disintegration of rocks into soil by agents like wind, running water, and moving ice.

What are the big ideas of this unit at this class level? Seeing variety in nature is surely one of these. Just as rocks are of a great variety, so are the soils. Another big idea is that 'variety-in-soils' is an effect, of which there must be some causes. Children can then be helped to see that soils are different because their parent rocks were different, or perhaps the disintegration was brought about in different ways.

The method of teaching here is mostly inquiry-oriented. Children are helped to discover for themselves that there is variety in soils and that this variety has a pattern. Through a number of activities they see for themselves how temperature variations, wind, running water and ice cause disintegration of rocks. Teachers should not simply tell these ideas to children. Rather, they should encourage them to make first-hand observations; on the basis of these, the teacher can help children to *develop* the understandings for themselves.

## 1. THERE ARE DIFFERENT KINDS OF SOILS

The underlying layer of rock known as bedrock is not visible everywhere above the earth's surface. It is covered over by water, sand or soil. The students have already learned that there is a great deal of variety in rocks. Here in this sub-concept they will learn that, like rocks, soil also has much variety.

### 1(a). SOILS DIFFER IN SIZE OF PARTICLES

Soils may differ in a number of ways. They may have strikingly dissimilar colours. They may have different textures: coarse, fine, gritty or soft. Sometimes even the difference in their odour may be quite characteristic.

Besides the above mentioned differences, soils may vary in the size of the particles which compose them. Actually the size of the soil particles gives it the characteristic feel. Bigger particles make the soil feel coarse and gritty. Very small particles make it feel fine and soft. The following activity will help children to appreciate this difference.

**Investigation**

**Do soil particles differ in size?**

*Materials required*
soil, paper,
hand lens

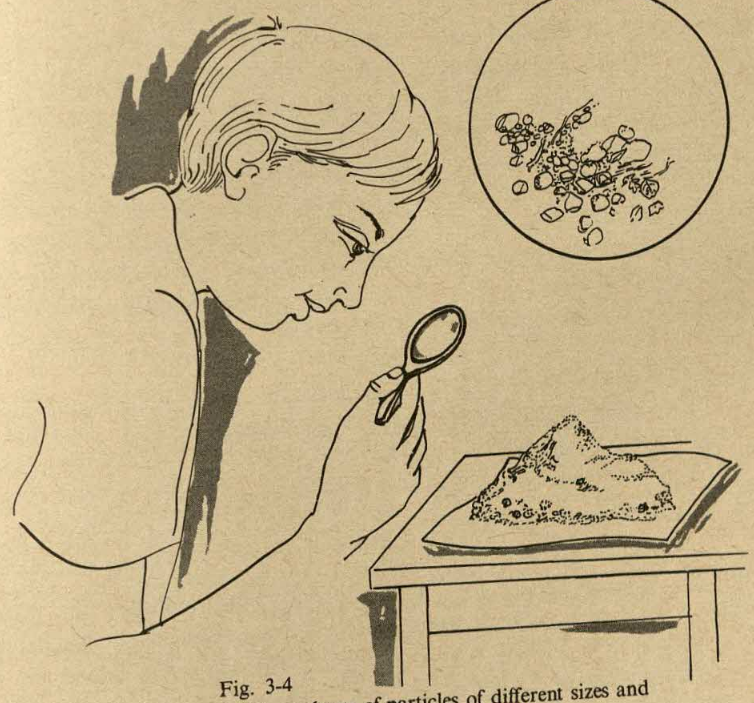


Fig. 3-4
Soil is made up of particles of different sizes and shapes.

Put a sample of soil on a piece of white paper. Invite children to examine this layer through a hand lens as in Fig. 3-4, and describe the differences in the nature of the individual soil particles they can observe. Some of them would surely note the differences in the size of particles. The children may now be told that the bigger particles are of sand or gravel and the smaller ones are often of clay.

*Ask children to pass some soil through a fine sieve. Let them handle the sifted soil and note the difference in its feel from that of the unsifted soil.*

*Ask children to collect samples of soil from different localities and compare the samples on the basis of the size of the individual soil particles.*

These activities show one basis of difference in various samples of soil. Some samples of soil may have a greater proportion of the bigger sand particles in them, while others may have more of the smaller clay particles.

**1(b).** SOILS DIFFER IN THEIR CONTENT OF ORGANIC MATTER

Gravel and clay are the two extreme limits of the tremendous variety possible in soils on the basis of variation in the size of constituent particles. Most soils include both sand and clay in different proportions.

Besides clay and sand particles, soils also have different amounts of organic matter. This organic matter is called *humus*. A sample of soil may differ from another in the amount of organic matter that it contains. Students may be helped to perform the following activities to have a better understanding of this concept :

**Investigation**

**How does organic matter differ from sand and clay?**

*Materials required*
three iron pans,
dried leaves,
sand, clay,
spirit lamp

Put a sample of organic matter like dried leaves in an iron pan, sand in a second pan, and clay in a third. Now heat the pans strongly. Help students to observe that, while the organic matter burns away and almost disappears, the clay and sand are left unchanged.

*Discuss with children why some materials get black on heating. This is so because they contain carbon.*

Of the three constituents of soil, only organic matter burns away on heating. This can be made the basis of another activity demonstrating variation in the organic contents of the soil.

**Investigation**

**Do soil samples differ in their organic contents?**

*Materials required*
three samples of soil, spirit lamp, three pans, balance and weights

Take three different samples of soil. Of these, one may be good garden soil containing organic manure, and the others may be from two other places (say, the roadside and a river-bank). The samples are dried separately by heating in open pans, as in Fig. 3-5a. This serves to drive out all moisture from the soil without allowing anything

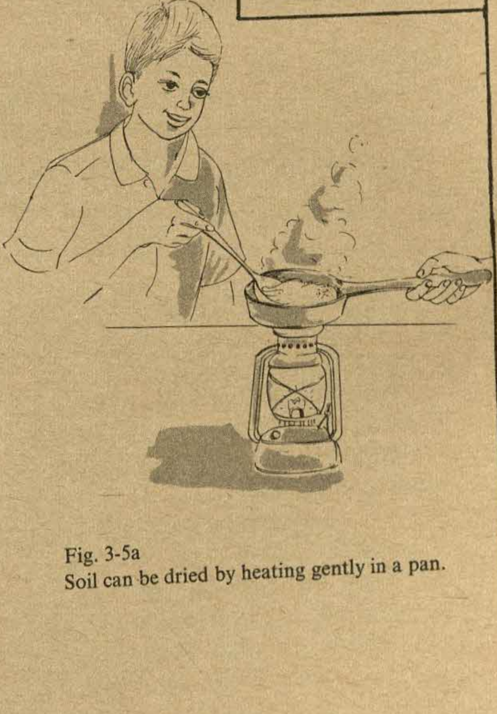


Fig. 3-5a
Soil can be dried by heating gently in a pan.

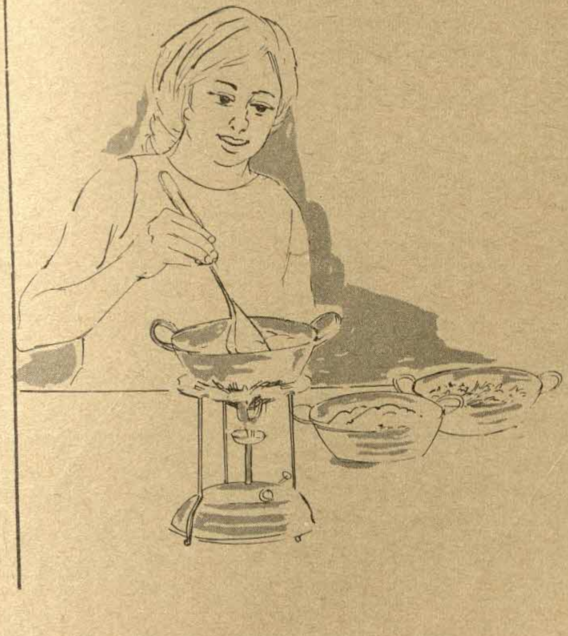


Fig. 3-5b
Soil can be heated strongly (or ignited) by heating over a hot flame.

to burn or decompose. Samples are now cooled. Equal quantities are then taken in three pans and heated strongly, as in Fig. 3-5b. After cooling, the samples are weighed. The teacher should help in performing the weighing operations in this activity. Ask children to calculate the loss in weight in each case. Which sample has the greatest amount of organic matter? They will discover that the garden soil has the largest amount of organic matter.

*Have children compare the odour of two soil samples—one from a fertile garden, and the other from a barren roadside. They will find that the garden soil has a distinct organic odour.*

**1(c).** CLAY, LOAM AND SAND ARE DIFFERENT FORMS OF SOIL

Children have seen as in Fig. 3-4 that soil contains sand, clay and organic matter mixed in varying proportions. In order to develop this concept further, students should be encouraged to examine soil in water as described in the following activity.

**Class Demonstration**

**What are the components of a good garden soil?**

*Materials required*
good garden soil,
glass jar, water,
string rod

Take a large glass jar and put a cupful of good garden soil in it. Almost fill the jar with water and stir with a rod. Take the rod out, and allow the contents to settle down. Invite children to observe the settling down of soil contents. Which portion of soil settles down first? (Small pebbles and sand). Why do they settle down first? (They are bigger and heavier). After the jar has remained undisturbed for an hour, ask children to observe the contents of the jar again. They will notice that a layer of fine clay particles is being formed among that of sand and pebbles. Why does the clay form the upper layer here? (Clay particles being smaller and lighter take a long time to settle

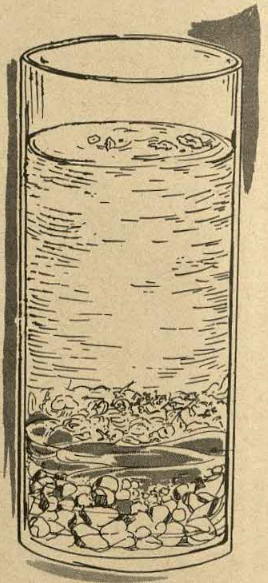


Fig. 3-6
Components of a garden soil can be separated by allowing them to settle in water.

down even if the water is motionless). Children may now be asked why the water is still not clear. This is due to finer clay and organic matter still suspended in water. The jar is again observed after it has remained undisturbed for a week. Children will observe (Fig. 3-6), layers of sand, clay and humus lying from the bottom upwards.

*Note:* In order to get good results, the teacher may prepare a sample of soil by mixing sand, clay and humus in almost equal quantities, say, a cupful of each. The layers will then the distinctly visible to children.

*Invite children to examine the texture of soils from a garden (loam), a brickyard (clay) and a sand hill.*

The amount of sand and clay may vary within wide limits in different samples of soil. The sand from a river-bank is also a type of soil. It differs from ordinary soil in that it does not contain much clay. Similarly, clay found by the side of a pond and used by the potmaker for preparing earthenware is also a type of soil. It differs from ordinary soil in being almost devoid of sand. The soil from tillable land contains both sand and clay. It is known as loam or loamy soil.

Besides being different in the shape and size of particles, sand and clay differ in their behaviour towards water. Clay takes up water and becomes gummy and compact. Thus it does not allow water to pass easily through it. In contrast, water passes through sand easily since there the particles remain separated. The following two activities will help children in appreciating this difference.

**Investigation**

**What is the action of water on sand, loam and clay?**

*Materials required*
sand, loam, clay
water

Give each child a sample of sand, loam and clay. Ask them to mix each separately with a little water, and try to mould the material into a spherical shape. Encourage them to describe the difference they observe in the respective behaviour of sand and clay. Sand does not hold its shape because the particles do not hold together. However, clay can be moulded easily (see Fig. 3-7) unless so much water has been added that it begins to stick to the hands. Loam is between these two in its behaviour towards water.

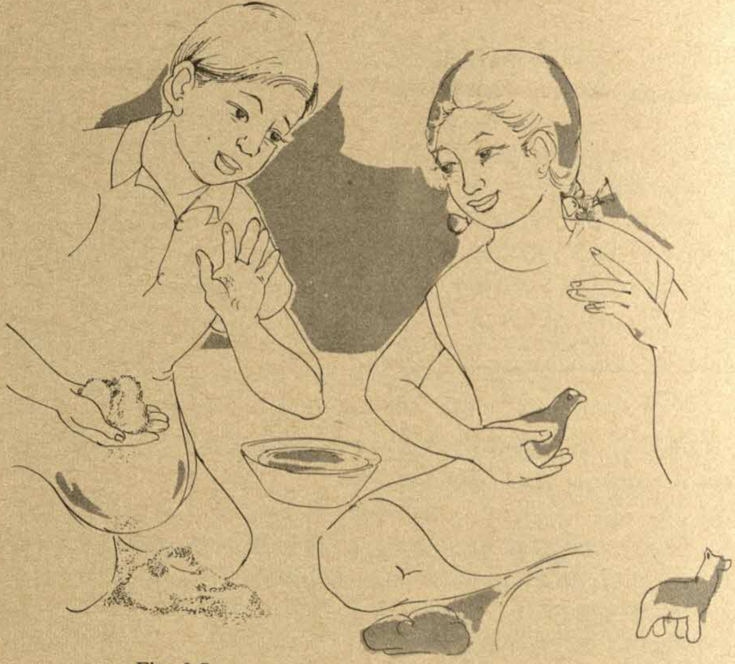


Fig. 3-7
Sandy soil tends to crumble, but moist clay can be moulded to shape.

*Encourage children to go to a potmaker's house and see him working at his wheel. Ask them to observe the raw materials he is using for making pots.*

**Investigation**

**Which allows water to percolate quickest—a layer of sand, loam or clay?**

*Materials required*
three cans, sand, loam, clay, water

Make five holes at the bottom of each of the three identical cans. Put equal amounts of sand, loam and clay with equal amounts of water in each can. Note the time taken by water for running out in each case. Children will observe that with sand it is the shortest and with clay the longest. Ask them why this is so. Clay particles being finer have smaller spaces between them and therefore reduce the drownward flow of water.

*Discuss with children why loamy soil is best for the growth of most plants. This is so because their roots need both air and water for proper growth. Clay retains water and sand allows air to pass through it. Loam is good because it contains both sand and clay.*

**For Better Understanding**

Soil forms the upper loose layer over most of the land upon this earth. It is formed by disintegration of rocks. How this disintegration is brought about through the agency of wind, water, etc., will be discussed in the next section. In the present section children are made vividly familiar with the variety met with in soils. Some may be eager to know the reason for this variety. Whatever the differences (e.g., related to colour, smell, feel), they must ultimately be due to a difference in composition.

Sand, clay and humus are the basic constituents of a soil. These constituents are chemically different. Sand consists mostly of a compound of silicon and oxygen ($SiO_2$). Clay consists of compounds of aluminium, sodium and potassium with silicon and oxygen. Because of their different chemical nature, sand and clay particles have different properties. Sand grains are harder, heavier and bigger. They cannot be easily broken down further. Clay particles are smaller and lighter. It is because of the small size of its particles that clay retains water so well. Sand has greater permeability for water, because its grains are larger, and so are the spaces between grains.

Ordinarily, good farming soil has both sand and clay in fair proportions. This soil is called loam. Sand gives loam porosity that is essential for the passage of air and water. Clay gives loam a sufficient degree of water-holding ability.

A soil is called sandy soil if it has large quantities of sand in it. A clay soil has large proportions of clay in it. Loam is sometimes characterized as 'sandy loam' and 'clay loam' depending upon whether it is a loam with much sand or a loam with much clay.

Soil is not an inert loose covering over the surface of the earth. It is not merely powdered rocks. It has a dynamic relationship with the plants and animals living upon it. For example, growing plants take away plant nutrients (compounds of nitrogen, phosphorus and potassium) from the soil. Some animals, like the earthworm, turn over the soil and thus loosen its texture. They are great assets to the farmer. Residues from plants and animals decay and then enrich the soil in organic matter. The roots of many of the pulses have attached to them a certain type of bacteria which converts atmospheric nitrogen into nitrogenous compounds. Therefore, a soil is enriched after a crop of some of these plants. Soil is thus very intimately related to the plants and animals of its surroundings.

## 2. DIFFERENT KINDS OF SOILS ARE FORMED BY DISINTEGRATION AND BY MOVEMENT

Students are by now familiar with the idea that there is a variety in rocks as well as in the overlying soil. It is quite natural for them to wonder about the cause of this variety. They may be encouraged to suggest answers to the question: "Would there be a relationship between the variety in rocks and the variety in soils?"

The concept of the relationship between rocks and soils is developed in this sub-concept through a series of activities. The children can discover that rocks have somehow broken down to produce soil which is made up of small particles.

**2(a).** ROCKS ARE WEATHERED BY EXPANSION, CONTRACTION AND BY FREEZING

Rocks are much larger than soil particles. Yet with a lens the children can discover that tiny pieces of rocks are similar in shape and colour to the bigger ones. The following activity will help children to discover this.

**Investigation**

**What is obtained when rocks are rubbed together?**

*Materials required*
two sandstone pieces, two limestone pieces, two shale pieces, hand lens

Rub two pieces of sandstone together and collect the powder thus obtained on a piece of paper. Repeat the same with the two pieces of limestone and two of shale. Ask children to observe these three samples of 'ground-down rock' with a lens. How do they compare with the original pieces? The students will easily notice that the grit obtained by rubbing sandstone pieces resembles the original rock sample in colour.

*Show children some sand and chalk dust. Ask them to say from what kind of rock these materials have been obtained.*

The breaking down of rocks into particles is called *weathering*. Children may be asked to suggest ways in which a rock might break into smaller pieces and then into fine particles. They have employed one way in the previous activity. What was it? Rubbing against one another. What causes this rubbing in nature? Some children might say that rocks may break when allowed to fall from a height. Gravity causes this fall. The following activity would assist the children in discovering a few more novel ways of breaking things in nature.

**Class Demonstration**

## Why does a glass vessel sometimes crack on heating?

*Materials required*
glass tumbler or
china clay dish,
metal tumbler,
lamp

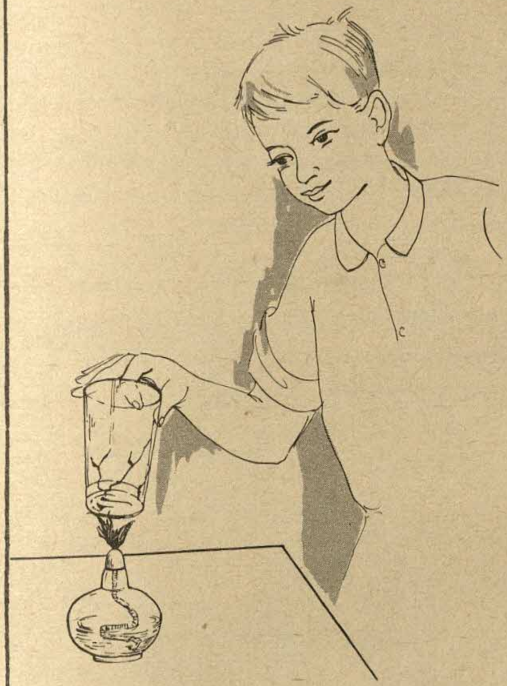


Fig. 3-8a
A glass vessel may crack on direct heating because:
(a) It is a poor conductor of heat.
(b) Different layers of glass are not heated uniformly.
(c) Strain develops among different parts of the glass.

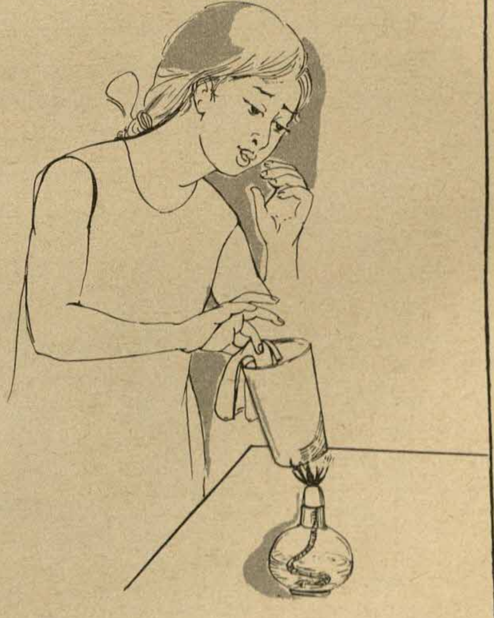


Fig. 3-8b
A metal container does not crack when heated.

Obtain a small thick-glass tumbler or an ordinary china clay dish. Heat the vessel on a naked flame. After some time, the pupils will notice that the vessel has cracked. See Fig. 3-8a. Encourage children to discuss why the glass vessel cracked, and why a metallic vessel under similar circumstances would not have cracked (Fig. 3-8b). Help children to understand that the glass vessel, while hot from outside, remained at ordinary temperature on the inner side (glass is a poor conductor of heat). The outer layers of the glass vessel expanded while the inner layers remained in their previous positions. As a result of strain among the different layers of glass, the cracks developed.

*Discuss with children why some glass vessels crack when ice is put into them. The inner layers get cool and contract. The outer layers of the glass vessel do not contract. A strain is again developed among layers. Hence cracks appear.*

It is seen from the foregoing activity that heating and cooling produce a strain among different layers of glass resulting in cracks. In a similar way, rocks crack because outer portions get greater heat and expand more than the inner portions that are not heated up to that extent.

Freezing of water helps in the deepening of rock-cracks developed by exposure to variations in temperature. This idea can be made clear to children through the following activity.

**Investigation**

**How does expansion of water during freezing crack a bottle?**

*Materials required*
a bottle with a secure cap, ice, salt

Fig. 3-9
Force developed in expansion of water during freezing may crack a bottle.

Invite a child to fill a bottle to the brim with water and to tighten the cap securely on the top. Wrap the bottle in a towel and cool it by putting it in a freezing mixture of ice and salt. Another bottle is filled not quite to the brim with water and tightly closed. It is also wrapped in a towel and placed along with the previous one.

When the temperature has fallen down sufficiently (about 5°C) show the children that neither of these bottles has developed cracks. Children may thus be helped to see that cooling alone does not crack the bottle. Cool down further till the water inside the bottles has frozen. Now remove the bottles, unwrap and observe. Children will notice that the full bottle has cracked, and the partially filled one has not, as shown in Fig. 3-9. Why has the bottle cracked? This resulted from the pressure developed within the completely full bottle during freezing. How did this pressure develop? As water began to freeze and turn into ice, it expanded. Since there was no space for expansion in this bottle, it broke. When some empty space was provided in the bottle for expansion during freezing, the bottle did not crack.

*In cold countries, exposed water pipes are covered over with a material that is a poor conductor of heat. Discuss with children why this is so.*

The fact that water expands when frozen into ice may be associated with the children's observation that ice floats on water. Ice must therefore be lighter than water. Ice occupies a greater volume than does its own weight of water.

Rocks are repeatedly heated up during the day and cooled during the night. As a result of this variation in temperatures, the rocks develop cracks. When water enters into these cracks and freezes, the cracks widen further apart, and the rock ultimately breaks away in pieces.

### For Better Understanding

The problem in this sub-concept is to convey to students how weathering breaks rocks down into smaller pieces. Several natural forces are involved in this process. Two have been discussed above. One originates in the different expansions experienced by outer and inner layers of rocks upon heating. The sun heats up the outer surface of rocks during the day. Rock-material is not a good conductor of heat. Hence the inner layers of rock, not directly exposed to the sun, are not heated as much as the outer exposed layers. Consequently they do not expand as much as the outer layers. A strain thus develops and the outer layer may crack. Cooling during the night has also the same effect, though in a different way. The outer exposed layers lose heat and cool down more rapidly than the inner ones. Again the contraction experienced by outer layers is more than that by the inner layers. This tension may result in more cracking.

Minor cracks, obtained in the above way, widen. Water that enters into them may freeze. The expansion of water on freezing produces the force that may widen the cracks and eventually break the rock.

**2(b).** WEATHERED ROCK IS TRANSPORTED BY EROSION

Soil does not always resemble the underlying rock. This is because the preliminary weathering may be followed by erosion, which moves pieces from one place to another. Soil is therefore not necessarily obtained by disintegration of rocks that lie directly beneath it. During the transportation of rock-fragments there may be further breaking down of rock-pieces.

Here are some activities to convey to children how the mixing of soil is carried out through wind, water and moving ice.

**Investigation**

**How does powdered rock differ from ordinary soil?**

*Materials required*
rocks, paper,
soil

Take two rocks and rub one against the other at their rough surfaces. Keep a white paper below these rocks during rubbing in order to collect the material that falls. Invite children to feel the rubbed surface. They will note that it has been smoothed. Examine the material collected on paper. It is a collection of small particles. How does it differ from the soil? There is no organic matter in it.

Rubbing produces soil-like powder. Let students now face this problem: "What causes the rubbing of rocks against one another in nature?" Invite their suggestions. Ask them if they have visited a mountain stream. How do the rock pieces found by the side of its banks differ from other rock samples they find? (In having smooth surfaces). Activities such as these will help students grasp this idea.

**Investigation**

**How does moving water help in the disintegration of rocks?**

If convenient, visit a mountain stream. Otherwise, simulate the situation by making a collection of rocks, and arranging them in such a way that there is a sharp slope. Put small pebbles on the upper surface (so that they may be shown to move along with rapidly running water). Now allow a rapid stream of water to flow from the higher end, as in Fig. 3-10. Help children to notice that moving water is carrying stones along with it. Since there are many stones being carried along simultaneously, they are rubbing against one another and also against the rocky bottom.

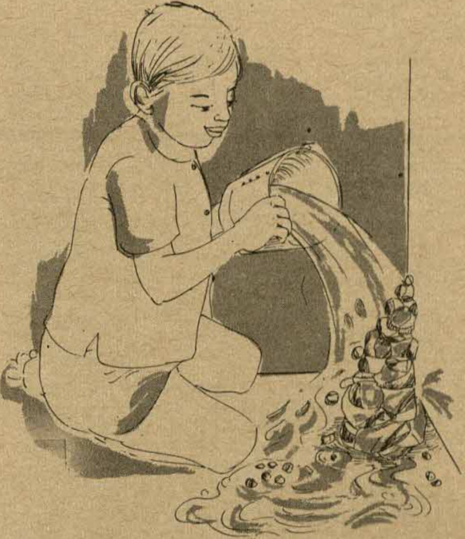


Fig. 3-10
Moving water helps in the disintegration of rocks.

*Discuss with children why a large number of rocks is used in lining an irrigation canal. This helps resist the disintegrating force of moving water.*

Just as running water can carry along stones, a swiftly moving blast of air can also carry along sand. The following activity will help children in appreciating this point.

| **Investigation** | **How does wind help in the disintegration of rocks?** | *Materials required*<br>fan, rocks, sand |
|---|---|---|

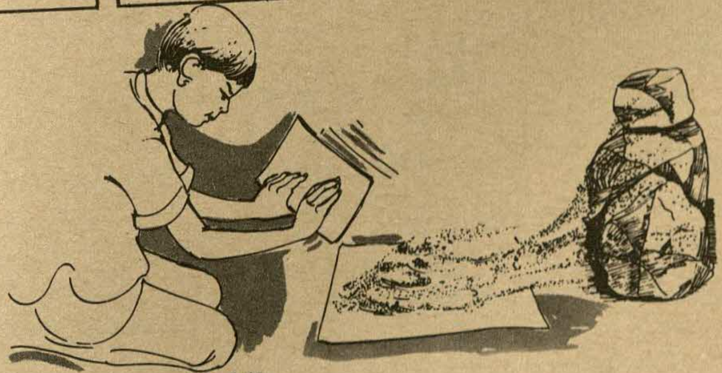


Fig. 3-11
Wind blows sand and helps wear away rocks.

Place some sand and rocks (up to about 2 cm in thickness) of varying sizes on a paper. A big rock is put near the end of this paper. Now, at the other end, a table fan or hand fan is moved first slowly and then gradually at a higher speed. Help children in appreciating how at slow speeds, the moving air strikes the surface of the bigger rock; and in this process moving sand particles rub against the rock surface, as shown in Fig. 3-11. At higher speeds, even pebbles may move along and rub against one another or with the rock that comes in their way.

*Caution:* Protect children from sand hurting their eyes or rocks hurting their bodies.

*Encourage children to narrate their experiences or those of their parents in a sand-storm.*

It may not be possible to demonstrate or show how moving ice disintegrates and carries rocks along with it. The following type of work may however be found useful.

**Discussion**

**How does movement of ice help in the disintegration of rocks?**

Narrate to children an account of some mountain expedition. Show them suitable pictures also. The purpose is to impress upon children that there are places so cold that water exists only as ice. A picture of a snow-fall upon mountains may also be shown to them. When the children are familiar with the idea that there are places with huge masses of ice, invite them to suggest what would happen if the ice blocks were to rest on a sloping surface. They would move down. Movement of ice, like that of water, would cause rocks to rub against one another.

*Display pictures of U-shaped mountain valleys. These have been formed by glaciers which gouged out V-shaped valleys into a rounded shape.*

## For Better Understanding

Initially, cracks develop in rocks, due to alternate heating and cooling. Water gets into these cracks. If frozen, this water deepens the cracks. Thus pieces of rocks are separated from the huge bedrock that had been exposed to the atmosphere. This process is known as weathering.

The sun is one important agent in weathering, for it heats up the rocks during the day. Heated rocks lose heat to the surroundings during the night. Water and ice are other important factors in weathering. Weathering refers only to the disintegration of rocks by exposure to atmospheric conditions.

The pieces of rocks, separated by weathering, can be transported by the process of *erosion* through three agencies: moving air, moving water and moving ice. When water or wind-blown sand or ice rub against rock, it is physically worn away. This wearing-down process is also included in the term 'erosion'.

Erosion differs from weathering. While weathering refers to only decay and disintegration of rock at a place, erosion means the wearing away and the transportation of the disintegrated rock. Thus, in a sense, weathering is static and erosion dynamic. The earth's surface is changing constantly by weathering and by erosion.

### Scientists at Work

### What kinds of questions do scientists ask?

You have learnt that rocks and soils are of a great variety. This is very good for us, because we can put them to a variety of uses. It seems the world is full of things that exist in great variety.

It is one thing to wonder at this great variety. You may exclaim at your friend's collection of rocks or soils—what a wonderful variety, so differently shaped and so nicely coloured! It is quite another thing to wonder *why* there is so much variety. In the first case you do not think further; in the second you continue to be curious.

Scientists are like ordinary persons and children in being curious. They not only wonder *at* their observations but also wonder *why*. They put forward trial answers to their own questions. These answers are such that they can be tested by experiment.

Let us start by being curious why soils differ from place to place. The differences among soils must have some cause. The scientist starts searching for the *cause* by analyzing first the *difference*. He asks: 'If soils are different, in what respects are they different?'

You analyzed samples of soil by stirring them in water and then allowing them to settle. This is the way a scientist collects experimental data. Many soil-samples are analyzed. Finally the scientist thinks that one way in which soils differ is in the relative proportions of the constituents: sand, clay and organic matter.

The nature of the question the scientist sought to answer now changes. Instead of inquiring, 'Why do soils vary?' he asks himself the question, 'Why do some soils have more sand (or clay or organic matter) than others?' This is an example of the way scientists work. They are curious about things around them. Their curiosity takes the shape of a question that leads them to an activity. At first, this activity is mental. From their previous knowledge, scientists conceive a good idea about the answer to their question. This idea about what the answer may be like is not a mere wild guess. Scientists call it a *hypothesis*.

A good hypothesis differs from a mere guess in that it can be tested. At times, two or more hypotheses are put forward as possible answers to the same question. A good hypothesis is one which can be tested—can be proved right or wrong by experimentation and observation. This helps in discarding all hypotheses except the one that is probably correct. Not only that, a good hypothesis leads further to new questions, new ideas and new activities.

Yet, the scientists' work is full of adventure. Try it yourself and feel the thrill!

# UNIT 3

# ROCKS, SOILS AND MINERALS

## CLASS IV

### Overview

Children have seen that rocks and soils are of different kinds. They have also learnt how different kinds of soils are formed from rocks by disintegration and by movement. But soil once formed does not remain in a static condition. As rocks change into soil, soils continue to change into new varieties.

The approach towards the study of soils is regional at this class level. From the point of view of a particular region, the significance of the four major concepts is evident in such questions as: 'How does the soil of the place vary with depth?' 'How does the soil change when water flows over it?' and 'How does it change when air blows over it?' Changes in soil discussed above are to be seen in reference to the living things which depend on the soil. Erosion and its prevention (conservation) then loom large as social problems.

The soil of any locality makes up much of its wealth. Plants grow in the soil. Animals feed upon plants. Man needs both plants and animals for his living. Agriculture depends upon soil. Building of houses, roads, wells are all in some way related to the nature of the soil.

Erosion is thus a social problem. Man always tries to check erosion and conserve the soil in its surroundings. The second and third major concepts of this unit relate to how running water and wind cause erosion. In the fourth major concept some methods of minimizing erosion and conserving the soil are discussed. The teacher should help children to use their knowledge of erosion to think out methods of checking erosion and conserving soil. The children can then learn to control the magnitude of effect by regulating the intensity of their causes.

One big idea of this unit is that change is a normal condition in the dynamic continuity of nature. Nothing is static in this world. Rocks undergo weathering and erosion, thus helping to produce top soil. Soil is washed away by running water and carried away from one place to another. Besides running over the surface, water also seeps underground. In this way water carries some of the top soil constituents into the subsoil. Along with physical agencies like wind, water, and ice, plants and animals also play an important role in bringing about changes in soil.

Though change is natural, man need not submit to these changes as if they were something inexorable. Man has tried to control these changes. He has been more or less successful. This struggle against nature can be illustrated by discussion of the methods of soil conservation. This is the second big idea in this unit.

## 1. SOIL IS FOUND IN LAYERS

Children now know that there is a variety in rocks, and also in soils. They have seen how rocks disintegrate and weather into the great variety of soil so obvious on the upper surface of the land. Instead of looking at soil samples of different places they can be invited to turn their attention to soil of any one place. The idea is to help them understand that there is variation in the nature of soil, even as one goes deeper down at the same place. Broadly speaking two different layers can be found: the topsoil and the subsoil.

### 1(a). THE UPPER LAYER OF THE SOIL IS TOPSOIL

While in some places bedrock is exposed, at many others it is covered by a layer of soil. Children may be asked to name a place where the layer of rock is exposed (this might be a nearby hilly area). Can they name a place where the layer of rock is covered by soil? (their play-fields). The thickness of the layer of soil is not the same at all places. As one goes deeper into the layer of soil, it is found that the type of soil changes. The following activity will help children appreciate this point.

**Field Observation**

**How does the soil vary with depth?**

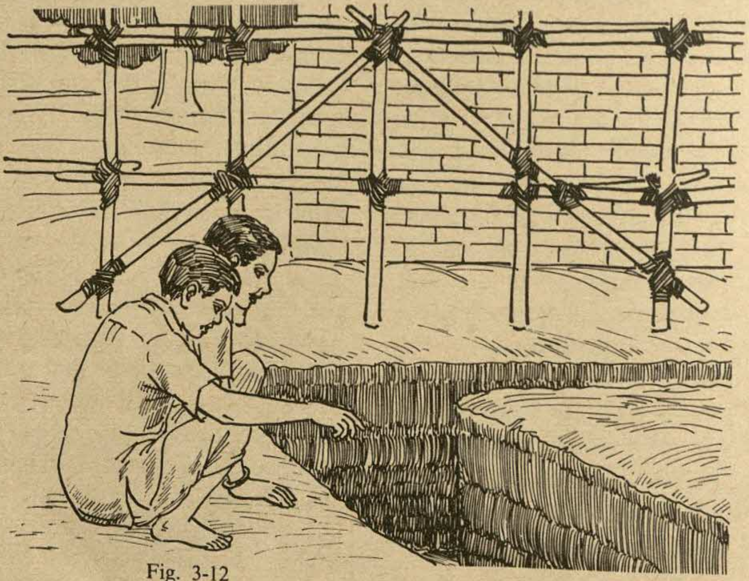


Fig. 3-12
Soil near the surface of the ground is often in definite layers.

Take children out on an excursion to a place where soil is being dug out for some purpose. One good place is where a house is being built. The visit should be at a time when the plinth has not yet been filled. Or students may be taken to a well which is being dug. Invite children to observe how the soil changes with depth. Help them to see as in Fig. 3-12 at least two different kinds of layers. The topsoil is usually darker and penetrated by the grass roots, while the subsoil is almost devoid of organic matter.

*Encourage children to find out the thickness of topsoil layer at some selected places in their locality.*

The upper layer of soil is called topsoil. It varies in thickness from place to place. It is in topsoil that the plants are cultivated. It contains organic matter (decaying leaves and plants) and is therefore of a darker colour. It is good for the growth of plants. Roots spread out and get their nutrients from this region.

### 1(b). THE LOWER LAYER OF THE SOIL IS SUBSOIL

On their previous visit, the children have seen that the soil exists in layers. They have noticed that the upper layer, called topsoil, contains organic matter and is often of a darker shade. Here, they will be able to examine some characteristics of the lower layers of the soil.

**Field Observation**

**How compact are the lower layers of the soil?**

Fig. 3-13
The lower layers of soil are more compact and more difficult to dig.

Again, invite children to a trip. A site where some excavation is going on may be selected. If no such place is available, students may be encouraged to get first-hand information about how the soil differs at various depths. They will find that it becomes more and more difficult to dig deeper, as in Fig. 3-13. They can observe that the lower layers are more compact, and do not contain much organic matter, such as decaying leaves. This layer of soil is called subsoil.

*Encourage children to take topsoil and subsoil in their hands. Ask them to tell the differences they observe in colour or smell or feel.*

**For Better Understanding**

An exposure of layers of soil is called a *soil profile*. The different layers are known as *soil horizons*. The uppermost layer is called topsoil or *horizon A*. It is this soil layer that is usually tilled for crops. It may vary in thickness from about 2 cm to more than 30 cm. It is rich in organic matter because it has been enriched by plants and animals.

During rains, when water sinks through the topsoil, it can become very moist. Soluble substances of the topsoil then dissolve in the descending water and are passed on to the lower layer of subsoil. This is known as *leaching*.

The subsoil is called *horizon B*. The parent rock material below the subsoil is called *horizon C*. The three horizons in a soil profile are not always discernible. The relative thickness of the topsoil and subsoil layers varies widely.

## 2. SOIL IS WASHED AWAY BY RAIN AND RIVERS

Children have seen that soil exists in layers. Now they will be helped to understand how soil moves from one place to another. This section deals with water as the cause of this movement.

### 2(a). SOIL WASHED AWAY BY RAIN WATER OR A RIVER IS DEPOSITED AT OTHER PLACES

There is hardly anything static in this world. Children may be helped to appreciate this by making cross references to the units on 'Air, Water and Weather' and on 'Our Universe'. Let them discuss what they know about movements of the sun, the moon, the earth, the air and water.

Soil is also being constantly shifted from one place to another under the influence of various physical agencies. Water is the most important of these. The following activities can help children in appreciating this point.

**Discussion**

### How is soil leached by rain water?

It would be best to carry out this activity on a rainy day. If this is not possible, encourage students to answer questions from memory. Some good questions are: How does rain water collected directly in a vessel differ from that which collects in a depression on the ground? Why is the latter of a different colour? Allow a sample of each of these to stand in two vessels. Why do we get a deposit in one and not so much in the other?

*Help children use a cloth to filter some muddy water. Ask them to evaporate the filtered liquid to dryness. They will notice a residue. This indicates that water dissolves substances from soil.*

As rain water falls on the ground, it loosens soil and gets muddy. This soil and other materials carried along by moving water are called *sediment*. So long as the water moves rapidly it carries the sediment along with it. Upon slowing down or coming to rest, the sediment sinks. Children may be shown (or asked to tell from memory) how tarred roads or pucca inner courtyards get covered with earth after the rain has stopped.

**Field Investigation**

### How are sediments deposited?

*Materials required*
a pan

Invite children on a trip to the bank of a river or stream flowing in the plains. Help them observe how the moving river water carries sediment. Children should be able to point out that much sediment settles down wherever the running water goes more slowly. Suggest that children hold a pan under the surface of running water. Ask them to take it out after five minutes and observe. They will see that soil is deposited in the pan.

*Discuss with children why river water is more muddy during the rains than in winter.*

The carrying away of soil by running water is not the entire story. There is another aspect of it—the deposit of sediment. This soil cannot be carried away indefinitely by running water. Sooner or later, depending on the flow of water, it settles down, and is *deposited.* Here are some activities which can help students grasp this idea.

**Investigation**

**How do slow movement of water and heaviness of particles help in sedimentation?**

*Materials required*
glass jar, sand, soil

Place a handful of sand or soil in a large round glass jar nearly full of water. Stir the mixture vigorously until all the soil is moving around with the water. As the water slows down children will notice that particles of the soil settle down, as shown below. Help children realize that the slower the water moves, the more apt sediment is to settle down. Also they can observe that coarse particles settle rapidly, while very fine particles may require hours to settle.

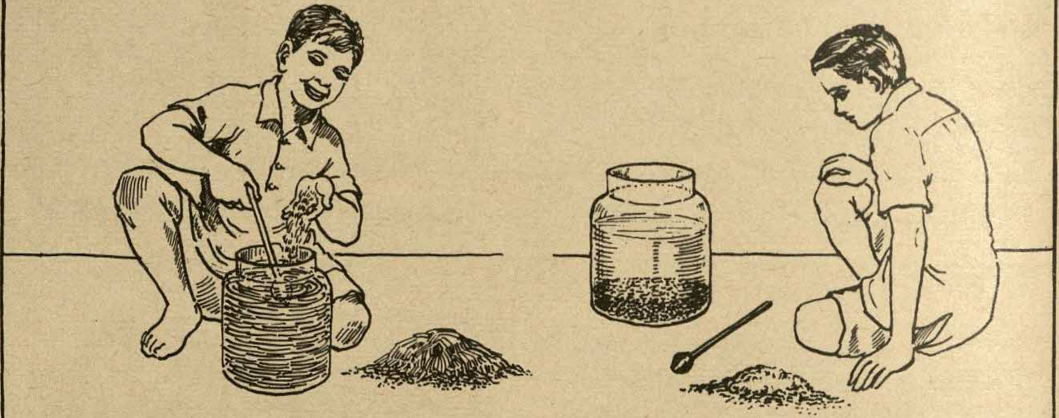


Fig. 3-14a

Fig. 3-14b

Sediment settles more quickly in still water than in moving water.

## For Better Understanding

Rocks break down and disintegrate into soil. This process is called *weathering*. There are various agents bringing this about in nature. Soil seldom stays at the same place after its formation. Water and air carry away soil from one place to another. This is known as *erosion*. To a community, soil is much of its wealth, since crops take root and grow in it. Erosion removes the soil and depletes the community of part of its wealth. Prevention of erosion is therefore a vital problem for all communities.

**2(b).** RIVER-DEPOSITED SOIL IS RICH

Children have seen how soil is being carried by water from one place to another. They also know that this soil is deposited at other places. A river flows very slowly just before it flows into the sea. Because it moves slowly, it deposits much soil. [See also the last activity under 2(a) of this unit]. The part of the land where a river meets the sea is called the river's *delta*. Children can appreciate the richness of the soil deposited by rivers through these activities.

**Discussion**

**How rich is the soil deposited by rivers?**

*Materials required*
pictures of river-side forests

Show children some pictures of river-side forests and shrubs growing in a desert. Discuss with them: Why is the growth so luxuriant by the side of a river? Why is it so scanty in a desert? Help them to understand that a river supplies both good soil and water to its valleys.

*In ancient times when man had learned to cultivate land, big cities grew up in river valleys. Discuss with children why it was so.*

The richness of the soil deposited by rivers is quite understandable. The river carries along with its waters vast quantities of soil and organic matter. Thus the river-deposited soil is rich in the sense that it contains much organic matter and other plant nutrients.

**For Better Understanding**

The fact that the soil deposited by rivers is rich in plant nutrients explains why the river basins are so fertile. The plains, through which many rivers flow, e.g. the plain between the rivers Ganges and Jumna, are therefore very rich areas for producing crops. That is also why such places were the candles of early civilizations.

The land which has been flooded by river water for some time is often found to yield a rich harvest of crops in the season following floods. This is due to the deposit of rich soil carried by river water.

Erosion by water at the hilltops brings down rich topsoil to the valleys. It appears that the valleys thus gain at the cost of hilly areas. If the erosion is not checked, the subsoil is also washed down from the hills into the valleys. This subsoil material will then hamper the proper growth of crops.

## 3. WINDS CAUSE EROSION

Running water is not the only cause of movement of soil from place to place. Wind also moves soil.

### 3(a). WINDS OFTEN BLOW THE SOIL AWAY

The effect of wind in erosion is not so obvious as that of running water. The following activities will however help children to understand the erosive effect of wind.

**Discussion**

**Why is it necessary to clean the window-panes every day?**

Ask children to clean thoroughly the windowpanes of their rooms on the outer side. Invite them to observe the carefully cleaned surfaces again after two hours. They will observe that dust has settled on the glass. They may now be asked what other evidences there are to show that air contains floating dust particles. Many will narrate their observations of dust storms during summer. Some might have felt the presence of dust when it got into their eyes.

*Discuss with children why the show cases of exhibits in a museum are often sealed.*

**For Better Understanding**

Wind is an important agent of erosion in deserts, along shorelines, and in other places where there is very little vegetation.

Though air almost always contains dust particles, it is only when wind blows hard that it becomes an important erosive agent. When the wind is strong, it also carries fine sand with it, and thus erodes even more.

Wind acts in two ways. It can blow out sand from an area and cause a depression there. The wind-driven sand also rubs against other surfaces and wears them away.

### 3(b). WINDS DEPOSIT SOIL AT OTHER PLACES

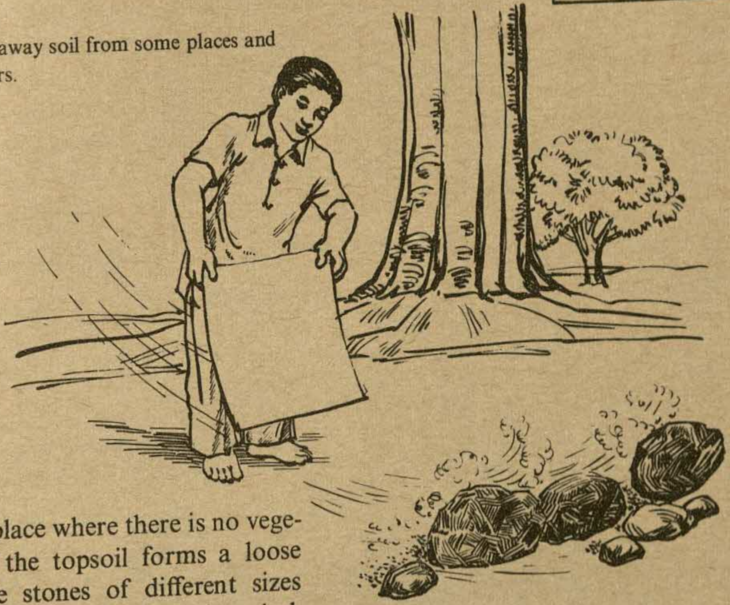
The soil carried by rapidly moving water settles down when the water slows down. The children may be encouraged to suggest answers to: what happens to soil carried by a strong wind, when it slows down? Some may suggest, via analogy, that the soil would settle down. They could now be invited to carry out the following activity.

**Investigation**

## How do winds deposit soil?

*Materials required*
cardboard piece,
loose soil

Fig. 3-15
Winds can carry away soil from some places and deposit it at others.



Select a place where there is no vegetation and the topsoil forms a loose layer. Place stones of different sizes to serve as obstructions to the wind. Use a large piece of stiff cardboard as a fan to blow the soil. Close to the fan, children will see that soil particles are carried rapidly by the air blast. Ask them about air-driven soil at longer distances from the fan. What about the movement of air at this place? It has slowed down. Children will see as in Fig. 3-15 that the soil is deposited when air slows down. Moreover, a larger quantity of soil has settled around the corners of the stones that were placed to serve as obstructions.

*Discuss with children how sand dunes are formed in deserts in almost the same way.*

### For Better Understanding

Wind erosion is most spectacularly seen near a sea coast or a desert. Sometimes loose soil is so completely removed that the bedrock is exposed.

The formation and disappearance of sand dunes is a common observation in deserts.

Shapes of sand dunes vary with the quantity of sand, strength of the wind, and constancy of its direction. When the direction of the wind changes, the dunes move from one place to another.

Erosion is not simply a loss of soil at one place and gain at another. It has a harmful effect at both the places and must therefore be controlled. Sometimes the wind-blown soil covers part of the plants. The plants still remain covered even when the wind stops blowing over. Such plants often die.

### 3(c). TOPSOIL IS EASILY ERODED BY WIND

Children have seen how erosion is caused by running water and blowing air. Let them now discuss how the action of water differs from the action of air. The following activity will help them arrive at a solution of this problem.

**Investigation**

**How does erosive action of water differ from that of air?**

*Materials required*
two piles of earth,
water, fan

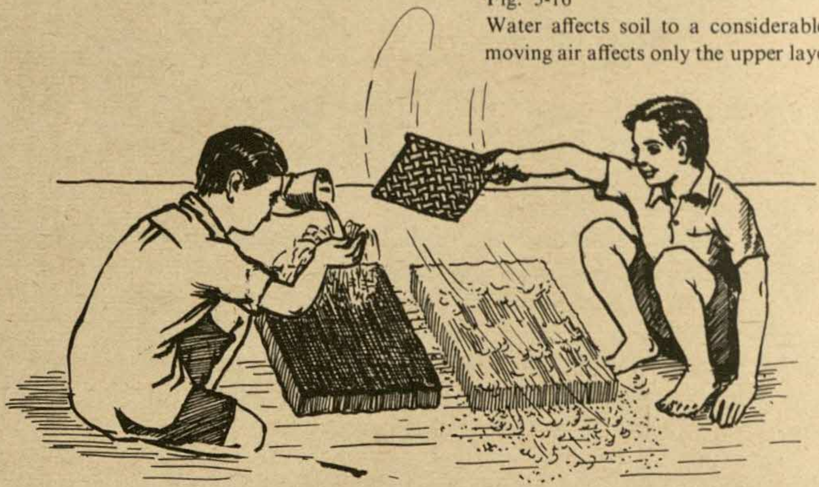


Fig. 3-16
Water affects soil to a considerable depth, but moving air affects only the upper layers.

Collect soil into two thick layers. Let there be two rectangular piles about 10-15 centimetres high and about one metre square. The tops of the piles are loose layers with some slope. Pour water at the higher level and allow the stream of water to flow for several minutes. At the same time produce a strong breeze across the other pile. Invite children to examine and compare the effect of water and that of air. Air leaves the lower layers of soil unaffected. However, the water gradually sinks down to them and moistens them. Soluble salts from the top thus reach the lower layers of soil. See Fig. 3-16.

*Spring water has often a peculiar odour or taste. Discuss with children why it is so.*

Wind erodes the topsoil most easily since it cannot penetrate to the lower layers. It is only when topsoil has been removed that subsoil comes under the influence of wind. Being a compact mass it is not so easily blown by wind.

### 4. SOIL IS CONSERVED IN MANY WAYS; IN EVERY CASE MAN ATTEMPS TO CONTROL THE MOVEMENTS OF THE ERODING AGENT

Children have seen how harmful is the erosion caused by water and wind. Erosion depletes a locality of its rich topsoil. Even when erosion from other places brings soil to a locality, this disturbs the delicate balance of topsoil and subsoil layers with the vegetation of the place. For example, subsoil from a place (from where topsoil has already been washed away) may be eroded and brought to cover the fertile topsoil of some region. Plants will no longer grow properly in this region because the plant nutrients are now in lower layers that cannot be reached by the roots. Children can now be encouraged to suggest ways to check erosion and the harm it does to the community.

No one can stop the waters of the earth from running or the winds from blowing. The eroding agents cannot be brought to a standstill. The best one can do is to slow down the movement of the eroding agent, or to make it move elsewhere, or to increase the resistance of the soil towards the eroding agent. This idea will be developed further in the following sub-concepts.

### 4(a). TREES AND GRASS HELP CONSERVE SOIL

The effectiveness of growing grass to prevent erosion can be illustrated by carrying out the following activities. The first of these involves setting up of careful controls. It is also a good exercise in the recording and interpreting of data.

**Class Project**

**How does grass conserve soil?**

*Materials required*
water, spare packing boxes, garden soil, grass

The activity is designed to compare the effect of water running over bare soil with that of water running over soil covered with grass. An arrangement of the type shown in Fig. 3-17 serves the purpose well. The two slanting surfaces are of the same area. They are covered with the same garden soil. One plot is left bare and the other covered with grass sod. An equal amount of water is poured over each plot each day. The run-off water is also collected separately and measured each day. The amount and colour of the two run-offs are recorded each day (water from bare plot will be

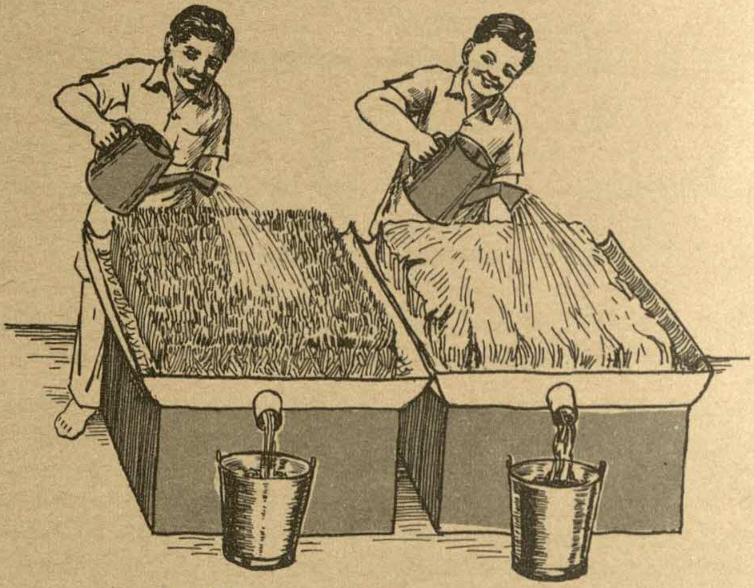


Fig. 3-17
Erosion can be controlled by growing grass.

found to be of darker colour). The results are tabulated as below:

Plot No. 1
With Grass

| Date | Water run on | Water run-off | Soil run-off |
|---|---|---|---|

Plot No. 2
No Grass

| Date | Water run on | Water run-off | Soil run-off |
|---|---|---|---|

Children will find that the water flowering out of plot No. 1 is less in quantity and contains less of the soil than the corresponding run-off from plot No. 2. The grass has an intimate relationship with the soil in which it is growing. The grass protects the soil from the full force of falling water by slowing down its movement. The grass also runs a network of roots through the soil. This network of roots holds together the soil against the running stream of water.

Accurate measurements of the water which flows from the plots (water run-off) and the soil which washes out of the plots (soil run-off) are time-consuming, but not difficult. The volume of water poured on the plots and the water run-off can be measured by using a small container as a standard of comparison. An empty cigarette tin or a glass tumbler is very satisfactory. Be sure to label which container is for plot No. 1 and which for plot No. 2.

To measure the soil run-off, the mud and silt which has been washed out from each plot must be gathered, and added to the proper water run-off the container. The muddiness will settle out of these samples better if a little alum is added to each container. After settling, decant off the clear water from the top, and permit the residue to dry out. Then it can be weighed.

*Ask children to put a few soda water bottle caps (edged downwards) on a layer of soil. On sprinkling water, they will find that soil below the caps is not washed away. Point out how in a somewhat similar way grass and other growth keep soil from being washed away.*

**Teacher Demonstration**

**How do grass roots prevent soil from being washed away?**

*Materials required*
tumbler, water,
soil with grass

Take a lump of soil along with grass thickly growing over it. Dip this two or three times in water. Children can see that the network of grass roots still holds some soil within its meshes.

The roots of other plants behave in the same way as do the roots of grass. They also protect soil from being washed away by water.

**Field Observation**

**How does lack of grass allow soil to be washed away?**

Take children on a trip to the fields where small irrigation channels are supplying water to the crops. Let the children discover places where (i) grass has prevented the soil from being washed away (ii) lack of grass is allowing soil to be washed away. Invite them to study and discuss the difference.

*Discuss with children why it is difficult to pull out the tap-roots of radish and carrot in their entirety.*

### 4(b). BUNDS OR LEVEES HELP CONSERVE SOIL

In regions where floods are frequent, erosion by running water becomes a serious problem. Children may be invited to consider the problem of floods. Heavy rains bring down water in quantities that cannot be managed by the normal drain channels. The level of water rises in the rivers so much that it overreaches the banks. The sides are eroded away by rushing water which spreads all around.

How, then, can the overflow of water be

checked? Drains, nullas, and rivulets may be provided with embankments that are sufficiently high to provide for the flow of excess water during the rains. At points where water strikes against the bank, the surface may be made specially firm and compact. A layer of stones or concrete covering may be provided. Children will appreciate the protective value of bunds and levees through the following activities.

**Discussion**

**How do dams check erosion of soil by water?**

Take children on a trip to some hydro-electric power station. Let them see the water falling from a height. Ask them what they think about the erosive action of water running very fast after a fall. Let them discover how a dam restricts the flow of water. The high and pucca embankments do not allow water to take any other course except the concrete one. *Note:* If such a place is not available in the neighbourhood, pictures may be shown to the students for working out the above ideas.

*During rains, water from roofs falls on the ground from some height in many houses. Discuss with children how the erosion of soil is checked in these cases.*

Bunds and levees are high, firm embankments to guide the flow of running waters into a prescribed course. They are like fortress walls protecting the vast surrounding area from the ravages of overflowing water.

**4(c).** TERRACING SLOPES HELPS CONSERVE SOIL

When water falls from a height it develops tremendous force. The water running down a hill acquires more and more speed during its downward flow. At the base such water causes extensive erosion. If somehow the downward flowing water can be prevented from gathering speed continuously, the erosive action can be reduced. Children can be helped to develop this idea through the following activity.

**Investigation**

**How does terracing of slopes conserve soil from erosion?**

*Materials required*
spade, water

Invite children to prepare two slopes of the soil which they have dug up. Make three or four terraces in one slope, and leave the other as a straight incline. Pour the same quantity of water at the top of the two slopes.

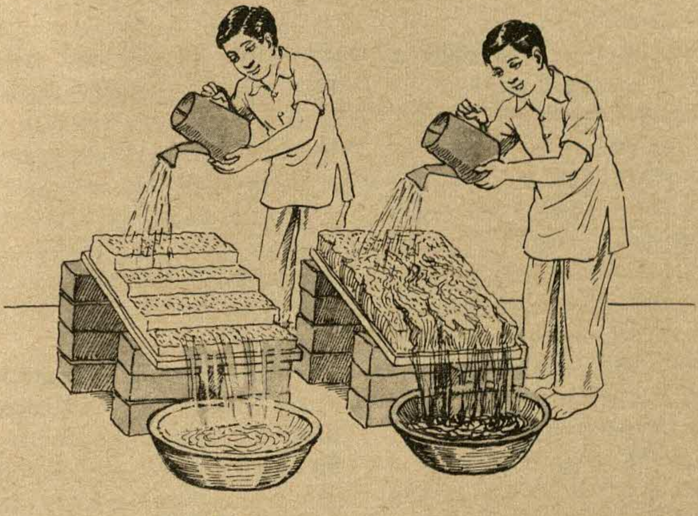


Fig. 3-18
Erosion can be controlled by building terraces in hill sides.

See how deep is the depression formed at the bottom of each slope as a result of running water. See Fig. 3-18. Why is it deeper in the case of the unterraced slope? Also notice that the water moving slowly down the terraced slope has more time to soak into the soil. Less water actually reaches the bottom of the terraced slope than the other one.

*Show children pictures of terraced farms on the hills. Invite them to answer why terraced fields are not found on the plains.*

Terracing is one answer to the problem of water getting faster in its downward flow and thus causing more erosion. In plains, there is no big difference in the levels of adjacent places. Hence there is no need of terracing.

**Scientists at Work**

## Geology becomes a modern science

You now know that scientists are keen observers interested in the collection and organization of data. To explain their observations, scientists put forward hypotheses that are tested by further experimentation and observation. Scientific knowledge continues to grow in this manner.

Our environment has many different types of things. There are the sun, the moon and the stars in the sky. There are air and water around us. There are plants and animals. The things to which we have been paying our attention in unit 3 are rocks, soils and minerals. Broadly speaking these things form the subject matter of a branch of science called *geology*. A person who studies about rocks and the minerals of which they are composed is known as a geologist.

The study of geology in the modern sense is about a century and a half old. In 1795, James Hutton published *Theory of the Earth with Proofs and Illustrations*. He put forward a very important hypothesis in this book. He said that in geology "the present is the key to the past, that the processes now at work on the earth must be studied, analyzed and used to read the record of the geologic past." James Hutton's book involved a very grand idea. It could have had tremendous influence on the progress of geology. Unfortunately the book was not well-worded; and it therefore passed almost unnoticed. Ability to communicate one's ideas exactly and effectively is an important tool for the scientist.

In 1802, John Playfair, a friend of James Hutton, published his *Illustrations of the Huttonian Theory*. Playfair expressed the ideas of Hutton so clearly that they were accepted by many geologists. The ideas were further developed by the English geologist Sir Charles Lyell in his book *Principles of Geology*, first published in the years 1830 to 1833.

Let us think about Hutton's idea again. It was not a trial explanation for some observations. It was a hypothesis only in the sense that it gave a new approach to the study of geology. Prior to the general acceptance of Hutton's ideas, scientists believed that the earth had gone through a series of sudden changes to arrive at its present state. Conditions for these gigantic changes were most unusual—nothing like conditions on earth today. Therefore no experiments could be used to explore the earth's past. But Hutton and Playfair believed that the earth's features came into being through gradual processes—processes much like those in evidence today. Thus Hutton's ideas were important in making the study of geology a modern experimental science.

## For Better Understanding

Erosion is an important social problem. The soil is much of the wealth of any community. Erosion deprives the community of its soil. Hence it is very crucial for a people to learn about ways of checking erosion. This checking of soil erosion is but one aspect of soil conservation.

What is soil conservation? It is an intelligent use of the soil for the community's good in such a way that efficiency remains at a high level even after a prolonged period. Conservation *does not* mean 'don't use the soil, save it for the future'. Conservation does mean 'use the soil wisely'. Besides checking erosion, soil conservation implies an intelligent use of fertilizers, suitable practice of crop rotation, and the avoidance of overtilling the soil. Fertilizers put back into the soil what crops have taken away. The term 'fertilizers' is used in a general sense to include all chemicals and natural manures that can be used for maintaining soil fertility.

Conservation is a very broad concept. Besides soil, it refers to many other resources of the community, e.g. rocks and mineral wealth, water, forests, and even the people (the human resource). In every case, conservation means intelligent use at present to be able to maintain efficiency for a long time in future.

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# UNIT 3

# ROCKS, SOILS AND MINERALS

## CLASS V

### Overview

Children have by now learnt how soil is formed by weathering and erosion of rocks. They see the importance of soil conservation for the welfare of a community. The emphasis of this unit at the class V level is on the discussion of rocks in relation to the minerals they contain.

The first major concept 'rocks are of three types—sedimentary, igneous and metamorphic' deals with a broad basis for the classification of rocks. A preliminary discussion of variety in rocks was done at the class II level. Children have seen that in spite of great variety in rocks, there are underlying patterns which can be made the basis for a system of classification. But this was only hinted at in class II. Here it is carried forward, although still at an elementary level. Children are now more mature. They can be taught the first broad basis of classifying rocks. The teacher can follow the scheme of classification further by looking into the section entitled 'For Better Understanding' given at the end of the first major concept.

The second major concept 'rocks contain minerals' deals with minerals as substances which make up rocks. In four sub-concepts, attempts are made to answer such questions as 'What is a mineral?' 'What forms do minerals have?' 'What are the most abundant minerals?' and 'How do metals occur in rocks?'

The third major concept 'rocks and minerals are useful to man' describes how rocks and minerals supply building materials for roads, dams and houses. The use of rocks and minerals in agriculture and in procuring metals is also taken up here.

The fourth major concept 'coal and petroleum are valuable underground resources' describes the occurrence and origin of these two most important fuels of the modern world. This brings the study of rocks and minerals very close to everyday life.

What is the important idea of this unit at the class V level ? It is that the pursuit of science leads to greater human control over the physical environment. When man's understanding of rocks was limited to something about their hardness and colour, he could put rocks only to limited use. But when scientific knowledge about rocks was extended to understanding the minerals of which they are composed, many more uses for rock materials were developed. Rocks can now be used to provide minerals for metals, minerals for agriculture, minerals for many chemical industries, minerals for fuel, and many other uses.

## 1. ROCKS ARE OF THREE TYPES: SEDIMENTARY. IGNEOUS AND METAMORPHIC

Students have seen that there is tremendous variety in rocks. They differ in colour, texture, hardness and in many other respects. Faced with this great variety, geologists have tried to formulate a system of classification for rocks. The following sub-concepts discuss the way rocks have been broadly classified.

### 1(a). SEDIMENTARY ROCKS ARE FORMED FROM DEPOSITS OF SEDIMENT

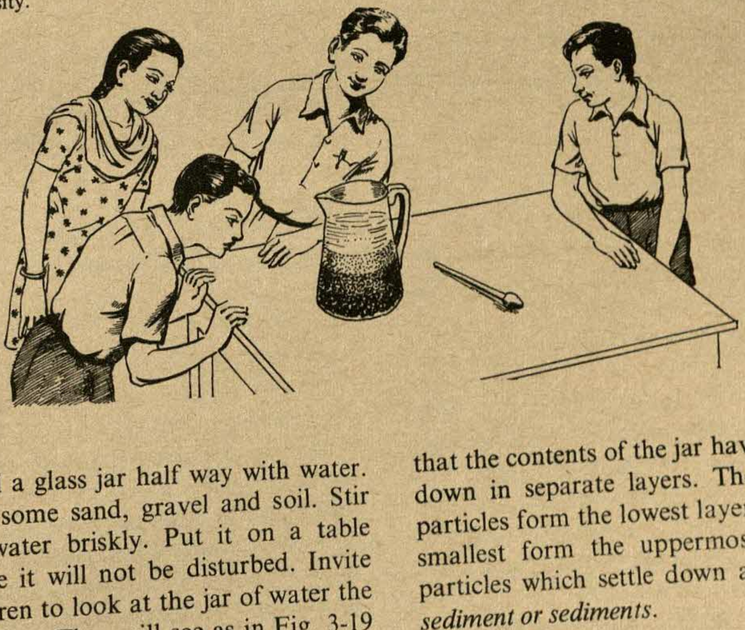
Rocks are classified on the basis of the way they were formed. The sedimentary type of rock is the most common and the easiest to understand. The formation of sedimentary rocks can be demonstrated to children by this activity.

**Investigation**

**How do sediments settle down?**

*Materials required*
glass jar, sand,
gravel, soil,
water

Fig. 3-19
Sediments settle in water according to their density.



Fill a glass jar half way with water. Add some sand, gravel and soil. Stir the water briskly. Put it on a table where it will not be disturbed. Invite children to look at the jar of water the next day. They will see as in Fig. 3-19 that the contents of the jar have settled down in separate layers. The largest particles form the lowest layer and the smallest form the uppermost. These particles which settle down are called *sediment or sediments*.

*Discuss with children why the sediments settle down in layers.*

The weathering and erosion of rocks is going on continuously. Children have seen that running water is an important eroding agent. Along with so much of water and dissolved matter, rivers bring tonnes of soil and sand to the sea. The sea-waves also wash away the shores against which they strike. All the insoluble matter thus brought into sea water gradually settles down to the bottom. This deposit, like the one in the above activity, is layered. The layering is because the largest particles tend to settle down first. As more and more layers pile up, the deposits are pressed together. This will be more clear to children from the following activity.

**Investigation**

**How does piling up of books increase pressure?**

*Materials required*
books

Invite a child to put his hand on the desk and lay a book on the top of it. Gradually put 2 or 3 more books above this book. Ask the child to describe what he feels. As more and more books pile up, the pressure on the hand increases.

*If there are five books in a pile, which one would be subject to the greatest pressure? Discuss this question with children.*

The layers of sediment that are being buried under more layers of mud and sand are submitted to very high pressures. This converts the layered sediment into a layered rock. Rock formed by pressing together of sediments is called *sedimentary rock*. See Fig. 3-20.

**1(b).** IGNEOUS ROCKS ARE FORMED FROM MOLTEN ROCK MATERIAL

The word *igneous* indicates origin by fire. Actually, igneous rocks result from the solidifying of molten rock material. This melted rock is called *magma*. Invite children to carry out the following activity in order to develop an understanding of what magma is like.

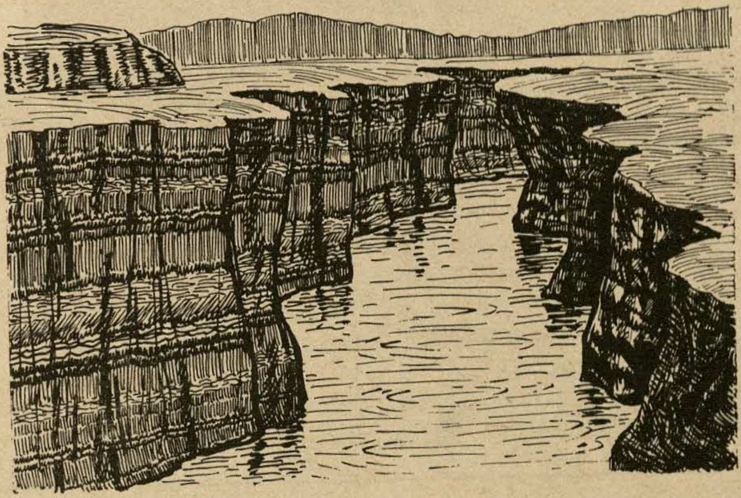


Fig. 3-20
Sedimentary rock usually shows the layers in which the sediments were deposited.

**Investigation**

**How does sealing wax change on warming?**

*Materials required*
sealing wax,
candle

Examine a stick of sealing wax. Let children feel it in their hands and see how hard it is. Warm the sealing wax at one end. Encourage children to describe the change in sealing wax developed on heating. It becomes a thick liquid flowing down the side of the stick.

Magma is like molten sealing wax. It is not thin and runny like water.

**Investigation**

**How does magma behave under pressure?**

*Materials required*
mud or dough,
cloth, thread, pin

Take some mud (or dough made out of flour and water) and put it inside a cloth cover. Tie the bag with a strong thread. Make a few pinholes in the cloth cover. Now press firmly on the package at one end. Help children notice that the mud (or dough) collects at the other end into an elevation. It then oozes out of the holes that had been made, as shown in Fig. 3-21.

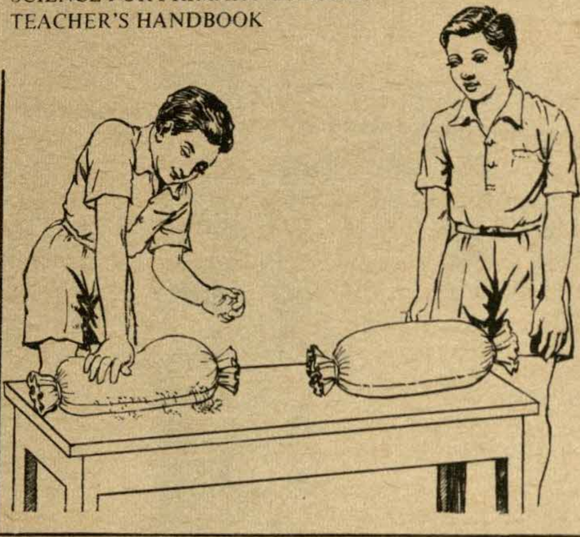


Fig. 3-21
Pressure on a bag of flour makes the contents move; sometimes rock within the earth moves because of pressure.

*Clay or flour becomes plastic on being mixed with the proper quantity of water. Invite children to name a few materials that become plastic or liquid upon heating e.g. glass, sealing wax, paraffin wax, or iron.*

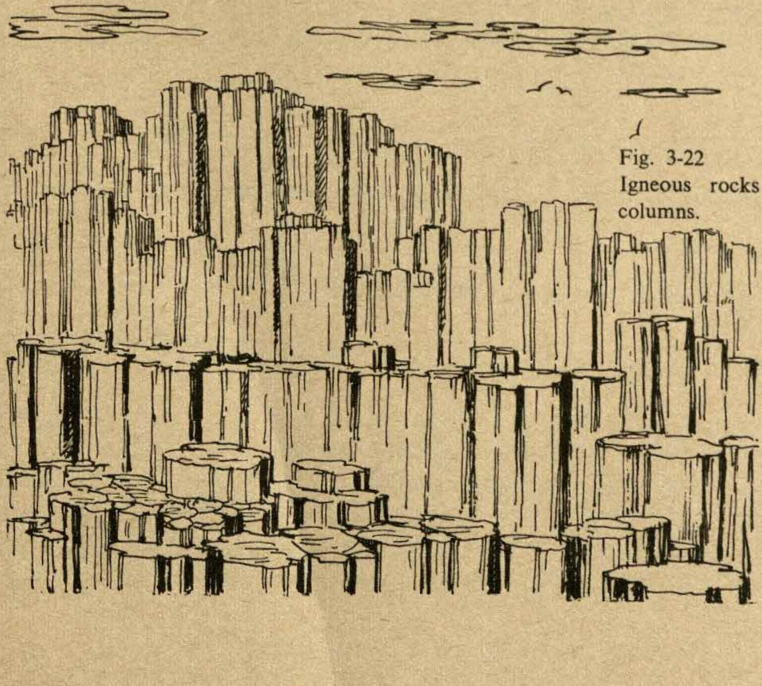


Fig. 3-22
Igneous rocks sometimes occur in distinct columns.

Magma is, in a sense, like mud or dough (of course it differs in being very hot). It is semi-solid. When pressed between layers it moves out to regions of lower pressure. In so doing, the magma may come outside the surface of the earth and flow as a hot, thick liquid. This is *lava*. Sometimes the magma is not able to flow out to the earth's surface. It cools down very slowly within the earth. The common igneous rock granite is formed in this way.

At some places the igneous rocks are columnar in structure. These were formed when lava came out in large quantities and formed thick layers. On cooling, vertical cracks developed in the mass of lava. The resulting igneous rock then looks like an assemblage of tall columns of different shapes, as shown in Fig. 3-22.

### 1(c). METAMORPHIC ROCKS ARE CHANGED FROM SEDIMENTARY ROCKS THROUGH HEAT AND PRESSURE

Metamorphosis means change. Metamorphic rocks were initially sedimentary rocks or igneous rocks. These underwent a great deal of change to become *metamorphic rocks*. Children will appreciate the nature of this change through the following activities.

**Investigation**

**How are metamorphic rocks folded?**

*Materials required*
twenty sheets of paper

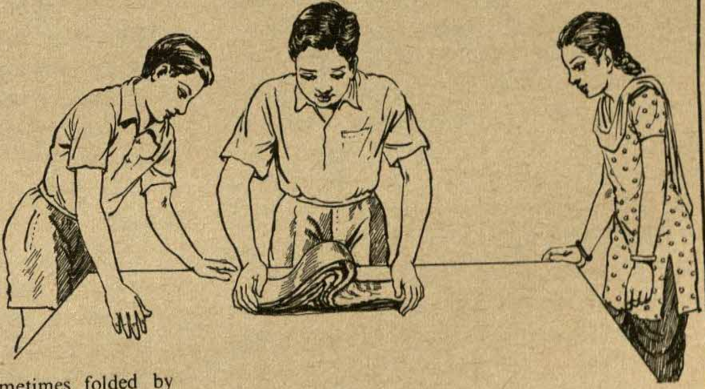


Fig. 3-23
Metamorphic rocks are sometimes folded by horizontal movements of the earth's crust.

Obtain some twenty sheets of paper fresh from the package. Stack them one upon the other. It is better to have them of three or four different colours. Encourage children to suggest what type of rock can be roughly represented by this arrangement. The layers of paper here represent sedimentary rock. Press the two ends of the paper pile with the palms of your hands. Move the hands closer so that the paper ends are brought nearer. Help children to observe that folds have appeared in the layers. Let them see how the top-to-bottom sequence of layers may be changed by this folding, as shown in Fig. 3-23. In what ways do the conditions within the earth differ from those of this activity? There is tremendous heat and pressure. Folding of paper was a human act, but folding of rocks inside the earth results from forces within the earth.

*Display common examples of metamorphic rocks, such as marble or slate. See also the section on "Classification of Rocks" at the close of this major concept.*

*Slate is a metamorphic rock. Discuss with children how its layered structure makes it useful for roofing and blackboard making.*

**For Better Understanding**

All rocks are really igneous in origin. Magma is the parent material for all of them. Chemically, the magma contains complex compounds of metals, silicon and oxygen. In spite of the high temperature within the earth, magma is not exactly a liquid. Due to very high pressure the melting point of magma is substantially increased. It remains as a thick viscous substance. Occasionally magma comes to the surface by breaking open a weak point in the earth's crust. The pressure is released. Magma then gets thinner in consistency and flows out as lava.

Igneous rocks differ because of differences in composition of the parent magma. The more obvious differences in texture and other physical characteristics are due to different rates of cooling. Granite is a coarse grained igneous rock formed by slow cooling. Basalt and obsidian are fine grained rocks formed by rapid cooling. Obsidian is natural glass but is usually so dark that light does not get through it. Pumice is an unusual rock with spongy appearance. Cooling of magma was very rapid in its case. Also, with the release in pressure over magma, much gas evolved leaving holes. Some pieces of pumice are so full of holes that they float on water.

After their formation, igneous rocks are subjected to erosion, just like any other rocks. Igneous rock fragments are carried by running water and deposited elsewhere as sediments. The sediments are *compacted* together into thick layers. The individual particles of sediment are *cemented* together to form solid rock—sedimentary rock. Such rocks are layered structures, and often contain fossils.

Examples of sedimentary rocks are: sandstone, limestone, shale and conglomerate. Sandstone is formed by cementing together of sand grains. The cement is calcite, silica, iron oxide or clay. Limestone is formed along the edges of large bodies of water by the accumulation of shells and skeletons of small sea animals. Conglomerate or pudding-stone is formed by cementing together of mud, sand and stones.

Metamorphic rocks are derived from igneous or sedimentary rocks. Banding is a characteristic of many metamorphic rocks. It means lining up of the flat mineral grains in a single plane. This gives the rock a tendency to split up in this direction. Mica provides a notable example of extreme layering of minerals. Not all metamorphic rocks are banded. Marble, for example, is often unbanded. Banding indicates that the rock has been subjected to pressure which caused movement of the grains of that rock. It is in the plane of this banding that metamorphic rock splits apart easily.

It is very tempting when studying about rocks to go into the classification of rocks and minerals. This is not the desirable thing to do here. It may be pointed out that scientists (geologists) do classify rocks for their own purposes. However, at this level, the classification into sedimentary, igneous, and metamorphic rocks is all that is desirable. Students may learn a few common names of rocks which are to be found in their communities. However, they should not be required to identify rocks and minerals in large numbers. If they wish, they can be encouraged to make their own system of classification of local rock samples. This will teach them much about systems of classification. It will also give them the very important ideas that classification is a human invention and that there are many ways to classify things.

### Classification of Rocks

Rocks are the raw materials of geology. The study of rocks is the basis and goal of most geologists' work.

Rocks are classified according to their origin into three major groups.

A. *Igneous Rocks*

These have been formed by the solidifying of molten material called *magma*.

**Examples**

(i) Granite: This is a light coloured coarse grained rock consisting of visible grains of quartz (clear or glassy), feldspar (white or pink) and smaller amounts of dark minerals such as black mica. Granite is extremely hard. Because of its decorative appearance and resistance to weathering, granite is a valuable building stone. Mixed with coal tar it is often used for surfacing roads.

(ii) Basalt: This is a fine grained, dark coloured, igneous rock. It does not contain quartz.

(iii) Obsidian: This breaks like glass to give shiny curved, rippled surfaces and sharp edges. Obsidian has a chemical composition like that of granite. During its formation from magma, it was cooled so quickly that crystals had no time to form.

(iv) Pumice: This is a porous rock with a spongy appearance. Some pieces of pumice are so full of holes that they will float on water.

B. *Sedimentary Rocks*

These are formed by compaction and cementation of sediments.

**Examples**

(i) Conglomerate or pudding-stone: This is made of rounded stones or pebbles cemented together into a solid rock. The pebbles are hard and resistant to weathering. They may be of different colours.

(ii) Sandstone: Here sand grains are cemented together into a rock. The grains may vary in composition, but most commonly they are of quartz. The cementing material in sandstone is usually calcite, silica, iron oxide or clay. When silica is the cement, rocks are very hard. Sometimes, there is an insufficient amount of cementing material and sandstone is porous. Such layers of sandstone would allow water and other liquids to seep through them. That is why sandstone layers are commonly the *reservoir rocks* in which petroleum accumulates.

(iii) Shale: This is a sedimentary rock made of layers of compacted mud. It consists mostly of clay minerals. It can be readily split into layers.

(iv) Limestone: This is a fine grained, fairly soft rock. It is largely made up of mineral calcite.

(v) Rock salt: This is the common salt, so easily recognized by its taste and solubility in water.

(vi) Coal: This is often considered to be a sedimentary rock of organic origin.

C. *Metamorphic Rocks*

These are rocks, obtained from previously existing igneous or sedimentary rocks, by the influence of tremendous heat and pressure.

**Examples**

(i) Slate: This is formed by the metamorphosis of shale under heat and pressure. It is harder than shale and is nonporous. It is a rock useful for preparing blackboards and for roof cover.

(ii) Marble: This is formed by the metamorphosis of limestone. It is coarsely crystalline in contrast to the fine grain structure of limestone.

(iii) Schist: This is formed by the further metamorphosis of slate.

(iv) Gneiss: This is usually formed by the metamorphosis of granite.

(v) Quartzite: This is formed by the metamorphosis of sandstone.

**The Scale of Hardness for Minerals**

Rocks are composed of minerals. A mineral is a naturally-occurring element or inorganic compound.

Hardness is the resistance that a smooth surface of a mineral offers to scratching. Under Moh's scale of hardness talc has been given a hardness of 1, and diamond the highest value—10. Names of minerals, in order of increasing hardness, are given below:

| Name | Hardness | Name | Hardness |
|---|---|---|---|
| talc | 1 | orthoclase | 6 |
| gypsum | 2 | quartz | 7 |
| calcite | 3 | topaz | 8 |
| fluorite | 4 | corundum | 9 |
| apatite | 5 | diamond | 10 |

## 2. ROCKS CONTAIN MINERALS

Rocks exist in great variety. Children know that many differences among rocks are due to their different ways of formation. Some of these however cannot be explained in the above way. For example, one rock may give off bubbles in acid and another may not. This is because the first rock has a different composition than the second. Minerals are the chemical materials of which rocks are made. The following sub-concepts relate to some common types of minerals.

### 2(a). MINERALS ARE CHEMICAL COMPOUNDS IN THE EARTH

Minerals are naturally-occurring inorganic substances with characteristic chemical composition and properties. They are the substances that form rocks. The following activities will help children understand this.

**Investigation**

### How are rocks composed of different minerals?

*Materials required*
rock with differently coloured minerals, puffed rice, fried gram, jaggery

Show children a cake made of puffed rice and fried gram with jaggery. Also show them a rock specimen such as granite in which differently coloured minerals are visible. Encourage them to understand the similarity in these two cases. Both are solids made up of distinct substances. The minerals composing a rock need not always be so nicely separated from one another. In some rocks two or more minerals are very thoroughly mixed.

*Encourage children to think out how the mixing of minerals was achieved. This was possible because the minerals were more or less fluid under the extreme hot conditions of the earth's interior.*

Minerals are inorganic substances composing rocks. What is meant by inorganic? The teacher can explain this term to students in connection with the word 'organism'. Living animals and plants are called organisms. Substances that are obtained from organisms (either living or dead) are called *organic*. The word inorganic carries a sense opposite to organic. Thus cane sugar from sugarcane plants is organic; and common salt from mines is an inorganic substance.

The relationship between the word 'mine' and 'mineral' is interesting. Minerals are often taken out from the earth by digging in mines.

A mineral, like any other substance, has distinct physical and chemical properties which help in distinguishing one mineral from another. Differences in properties of minerals result from differences in their composition. Yet each mineral has a definite composition in the sense that it is composed of the same element or elements combined in definite proportions.

The idea that the properties of the whole often depend on the nature of the component parts may be conveyed to children through the following discussion.

**Discussion**

### Do chapatis and poories look and taste different?

Most of the children have eaten chapatis of wheat, maize or bajra flour. Engage them in a discussion of the ways these three chapatis differ from one another. For example, they may differ in colour taste. shape and size. What is the cause of this difference? The chapatis differ in the nature of the material of which they are made. Similarly poories made from wheat flour, or wheat flour mixed with sugar and milk will feel and taste different. The reason is that they differ in their composition. In a similar way minerals differ from one another because they have different compositions.

*Challenge children to name four different materials used for making household utensils. In what ways are their properties different?*

**2(b).** MOST OF THE MINERALS FOUND IN ROCKS HAVE A CRYSTALLINE FORM

The idea of a crystal can be introduced to children through an activity of the following type.

**Investigation**

**What are crystals like?**

*Materials required*
common salt crystals,
lens

Give a few selected crystals of common salt to each child (some good crystals may be selected from 'sambhar') for examination. Let them handle these

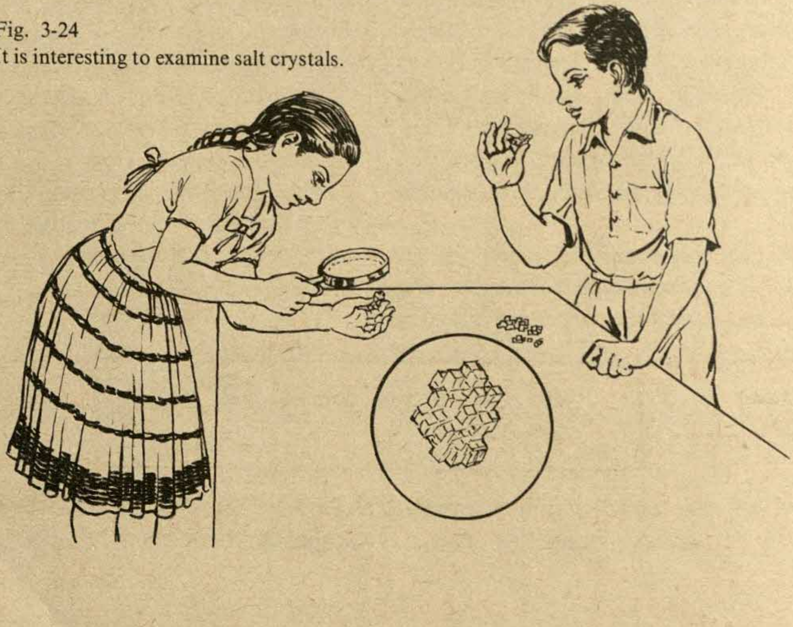


Fig. 3-24
It is interesting to examine salt crystals.

pieces of common salt and, if possible, also observe them through a magnifying glass. Invite children to discuss: How do the pieces resemble one another? They will discover that even though the various pieces differ from one another in size, they have the same shape, as in Fig. 3-24. What shape is it? It is cubic. Let a child break one of the bigger pieces. He will find that the smaller pieces obtained by breaking have much the same shape as the original piece. How do pieces of rock differ in this respect from crystals of common salt? They do not have the same shape, and they do not break down to smaller pieces of identical shapes. Help children in observing that, while some common salt crystals are perfect cubes, others are not so shaped. This will lead them to the problem: How can we get good common salt crystals?

*Show sugar crystals to children. Invite them to suggest a way in which sugar crystals may be distinguished from common salt crystals. (Through a hand lens salt and sugar crystals are seen to have different shapes. Also, sugar burns while salt does not. There is a difference in taste too, but in general the tasting of chemicals is a dangerous practice.)*

**Investigation**

**How can we prepare crystals of common salt?**

*Materials required*
glass jar,
glass tumblers,
common salt,
papers with holes

Put 1/2 litre of water in a glass bowl. Mark with a pencil the top layer of water. Let the children put some refined salt into it. Stir. The salt disappears because it dissolves. Ask them how they can know that the water contains salt. The taste will be salty because of the dissolved salt. Let more salt be added and the contents stirred. Repeat until some of the salt remains undissolved. Help children to observe that there is a limit beyond which salt cannot be dissolved. Such a solution of salt in water is called a *saturated solution.*

Distribute this saturated solution among children. Glass tumblers may be provided for the purpose. These are covered with pieces of paper pierced with holes. The solutions are kept undisturbed for about a week. Invite children to look at the tumblers occasionally. They will observe that the level of water begins to go down in the tumblers, and some solid separates out at the bottom. The level falls because water evaporates. Solid salt separates because the smaller amount of water cannot hold the original quantity of salt.

When the water has evaporated, children can examine the crystals, as in Fig. 3-25. Or they can spread the crystals on a piece of paper and allow them to dry.

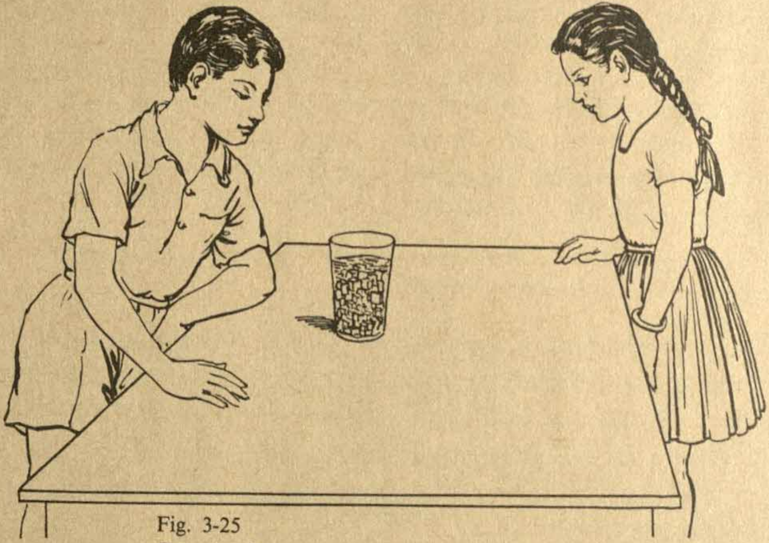


Fig. 3-25
Crystals of common salt can be prepared from its saturated solution.

*Ask children to name a few solid substances that they have seen as crystals, e.g. sugar, alum, blue vitriol.*

Children have now a preliminary acquaintance with crystals. The idea that most minerals found in the rocks have a crystalline form can be imparted to them through an activity of the following sort.

**Investigation**

**How does crystalline form help in identifying crystals?**

*Materials required*
calcite, quartz,
common salt

Place before a child a collection of several minerals (e.g. calcite, quartz) having different crystalline forms. Ask them to separate the minerals from one another by taking help of the characteristic crystalline form.

*Invite children to make drawings of the crystals they have observed.*

**2(c).** SOME MINERALS ARE VERY COMMON

One of the most abundant of igneous rocks is granite. This is largely composed of (a) quartz (b) feldspar and (c) mica. Of these three, quartz and feldspar are light coloured; mica is sometimes dark coloured. Since granite is a very common igneous rock, the minerals composing it should also be very abundant. Of the above mentioned three minerals, quartz is the most abundant and mica the least.

**Discussion**

**How is the abundance of elements related to abundance of minerals?**

Invite children to discuss (Fig. 3-26) about the relative abundance of elements in the earth's crust. Here are the data.

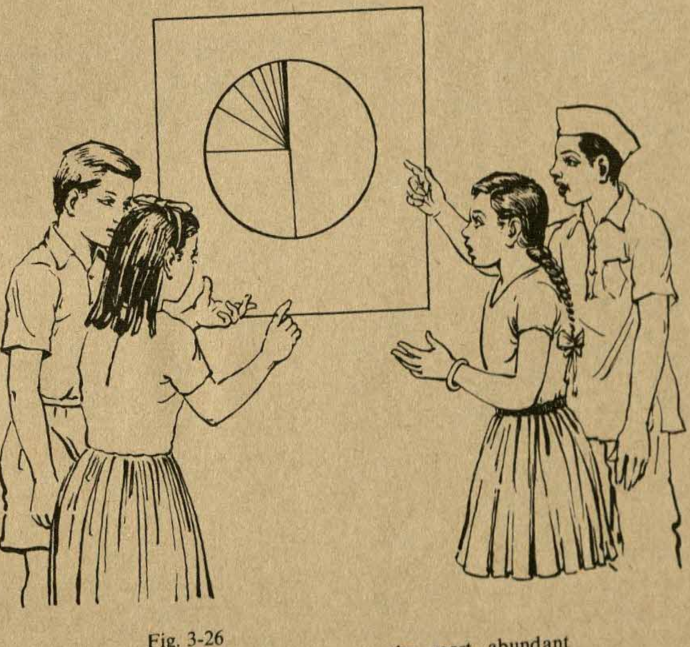


Fig. 3-26
Oxygen and silicon are the most abundant elements of the earth's crust.

| *Rank* | *Element* | *Relative abundance in per cent by weight* |
|---|---|---|
| 1 | oxygen | 49.13 |
| 2 | silicon | 26.00 |
| 3 | aluminium | 7.45 |
| 4 | iron | 4.20 |
| 5 | calcium | 3.25 |
| 6 | sodium | 2.40 |
| 7 | potassium | 2.35 |
| 8 | magnesium | 2.35 |
| 9 | hydrogen | 1.00 |
| 10 | others | 1.87 |

Children can be told about the composition of the three minerals present in granite. Quartz contains silicon and oxygen in chemical combination. Feldspar contains aluminium, sodium and potassium in addition to silicon and oxygen. Mica contains silicon, oxygen, aluminium, and potassium, together with a little iron and magnesium. The teacher can help the students to correlate these two kinds of information. Since quartz and feldspar are so common, the elements oxygen, silicon, and aluminium are the most abundant.

*Discuss with children why the percentage of hydrogen is only* 1.00, *even though three-fourths of the earth is covered by water. (Hydrogen is the lightest element. Hence, although it is abundant, its percentage by weight is low).*

### For Better Understanding

It is true that students at this class level have had no formal introduction to concepts relating to elements and compounds. This is one place they can get an advance look at these ideas. They can be told that all materials are made up of one or more elements. Although there are over 100 elements known, most common materials are made up of twenty or so of the elements. Many of the elements have common names and are familiar to children. Among them are oxygen, nitrogen, carbon, iron, gold, chromium, silver, lead, copper, aluminium, and tin. Although they may not have seen them, children are also usually familiar with the names of such elements as hydrogen, helium, iodine, and mercury.

This is not the time to teach chemical symbols formally, although they may be introduced if the students seem interested. By no means should students be required to memorize names or symbols of elements, nor the order of abundance of elements in the earth's crust. The objective of science instruction is understanding, not mere memorization.

## 2(d). METAL ORES OCCUR AS MINERALS

Children know what a metal is. They can name some common metals: iron, copper, silver, gold, and aluminium. From where are these metals obtained? Children will probably answer: "From the market or from the mills." One or two might answer: "From the interior of the earth". A discussion such as the following can be used to develop this understanding:

**Discussion**

**What do metals look like when first taken out from mines?**

*Materials required*
pictures of mines and minerals

Show to students pictures of iron, copper or gold mines. Also show them the minerals as obtained from the mines, e.g. the ores from which the metals are produced. Children will observe that some metals, e.g. gold and copper are found in metallic form in the earth, while others are not. The teacher can help students understand that in such cases the metal exists in combination with other elements. A great deal of processing of the ore is done to obtain the metal in such cases.

*Invite children to name a few natural products that are first processed before being used by man, e.g. cane sugar, cotton, rubber.*

**For Better Understanding**

The form in which a metal is taken out of the earth, is called the *metal ore*. Metal ores are minerals that compose the rocks. Although all ores are minerals, not every mineral is an ore. A mineral is thought of as a metal ore when some metal can be extracted economically from it. Thus, feldspar is a mineral containing the metals aluminium, sodium and potassium. But it is not an ore for any of these three metals, since these metals cannot be extracted from it economically.

## 3. ROCKS AND MINERALS HAVE MANY USES

Children are now familiar with different types of rocks, and a few common minerals and ores. The teacher can now discuss with them why rocks and minerals should be studied. One answer may be: "They form part of our environment and there is so much interesting variety in them." The teacher can add that rocks and minerals should also be studied because they are useful to us. One use with which children are already familiar is that rocks disintegrate and produce soil. Students can learn about some more uses of rocks and minerals in the sub-concepts which follow.

### 3(a). ROCKS ARE USED IN MANY KINDS OF CONSTRUCTION

Students know that stones are pieces of rock and that they are used in the construction of buildings. To help children have a fuller appreciation of the vital importance of rocks for our civilization, the following activities are suggested.

**Field Observation**

**In what different ways are rocks being used today?**

Take children to inspect a stone building. Ask them in what ways rock pieces are being used (for erecting walls, for roofing and flooring, and smaller pieces for ornamental purposes). Show them some stone statues or carvings. Pictures of Ellora and Ajanta caves may be shown if a statue is not available in the vicinity. Children thus see that rocks have been used from early times (i) for architecture and (ii) for sculpture.

*Ask children to describe what 'stone age' means. In what way were rocks possibly used in those days?*

Such an activity teaches them about the use of stones in early times. Are rocks being used even now for these purposes? Students can be taken on excursions for an answer to this question.

**Field Observation**

**In what ways are rocks and minerals used nowadays?**

Visit places where a house, a temple or some other large building is being constructed or where a dam or a road is being constructed. If a visit is not possible, show students appropriate pictures. Engage children in a discussion on the question: "In what ways are rocks being used for the above-mentioned constructions?" Help students to appreciate how important are stone pieces, sand and lime for such constructions. Show them charts depicting the manufacture of cement and lime. Let them note that the mineral gypsum is important for cement manufacture and the mineral limestone for obtaining lime.

*Ask children to name domestic articles made of rock ('chakla', sil-batta', 'pathrauta', 'kharal').*

### 3(b). SOME MINERALS ARE USED IN AGRICULTURE

From the study of unit 3 the students know that all soils are not equally suitable for the growth of plants. By repeated cultivation some soils lose the essential food elements for plants—nitrogen, phosphorus and potassium. How does a farmer enrich his field-soil? By adding natural manure which supplies all the elements of plant food in small quantities. There are also some fertilizers that supply plant food in a concentrated form. Here is a way to help children learn about these concentrated fertilizers.

**Discussion**

**How are minerals used for preparing fertilizers?**

*Materials required*
*assorted minerals, fertilizers*

Show children some fertilizers: nitre, sulphate of ammonia, nitro-chalk, superphosphate of lime. Read to them methods of their preparation or describe to them their methods of manufacture. Help them see that gypsum is a mineral used for the manufacture of ammonium sulphate (in Sindri fertilizer plant). Tricalcium phosphate is a mineral used for the manufacture of superphosphate.

*Ask children to discuss with their parents what fertilizers are used for tomato and potato.*

### 3(c). SOME ROCKS CONTAIN USEFUL METALLIC ORES

Children have already learnt under the sub-concept 2(d) for class V that ores occur as minerals. The two sub-concepts somewhat overlap each other. The previous learning will be reviewed by asking: "How do metals occur in nature?" A very few metals including gold and sometimes copper occur in the free state (i.e. as metals) in nature. Mostly metals exist in nature in combination with other substances. Ask children: "How are metals obtained from such combinations?" Invite them to follow the extraction of a few metals through pictures.

**Discussion**

**How are metals obtained from their ores?**

Show children pictures of the processes involving extraction of iron (the blast furnace), copper and aluminium. Help them to appreciate that coal is an important material for getting iron from its ore, as in Fig. 3-27 and electricity is consumed in the extraction of aluminium and refining of copper. Other common metals may be similarly discussed.

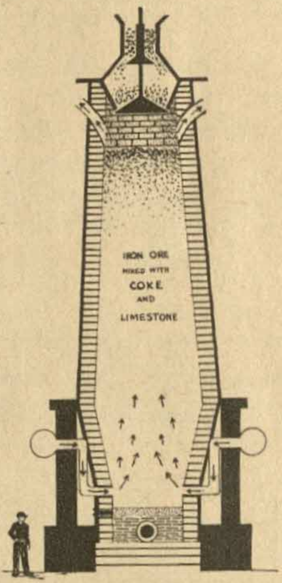


Fig. 3-27
Iron obtained from its ore, in a huge blast furnace.

*Discuss with children why only a few metals like silver and gold occur free in nature. This is because they are inactive. They do not combine with other elements easily.*

**3(d).** METALS ARE WIDELY USED IN INDUSTRY

Metals are extremely useful in the modern world. Scientists are continually finding ways to make metals better and more useful. Here are some activities which can help students appreciate the many ways in which metals are used.

**Discussion**

**Are large quantities of metals used by some industries?**

Invite students to start thinking about industries by looking at articles used in homes. The kitchen invariably has a number of metal utensils. Of what metals are these made? Help children to visualize that there must be an industry which makes utensils. And it must be using large quantities of metals as raw material. Coins are made of metals such as copper, nickel, silver and aluminium. Coinage requires large quantities of metals. Invite the attention of children to such items as gasoline engines, railway engines, rail tracks, aeroplanes, ships. Help them to realize what large quantities of metals are used by industries.

*Let the class debate on the topic—which is the more important metal, iron or gold?*

Certain articles are non-metallic in nature: cane sugar, cloth and plastic. Yet, the machinery used in their manufacture is largely metallic.

**Discussion**

**Are metals important for industries producing non-metallic things?**

Make an excursion to a sugar mill or textile mill, or a factory for preparing artificial ghee. If it is not possible, show pictures giving a description of these mills to children. Help children in appreciating what large quantities of metals are needed for the preparation of basic machinery.

*Discuss with children how huge quantities of iron are used in the construction of buildings, dams and bridges.*

Metals are thus in great demand. And so are the metallic ores from which these metals are obtained. A search is constantly underway for locating areas in which metallic ores are present in sufficiently large quantities. A guided discussion can show how metal producing factories are located.

**Discussion**

**Where are industries for extracting metals located?**

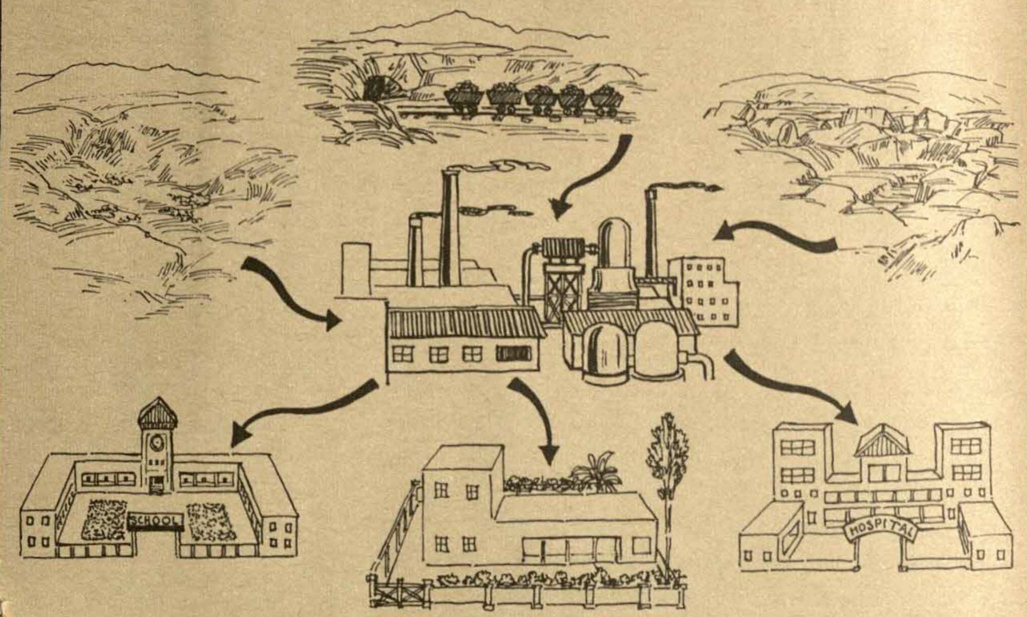


Fig. 3-28
Factories which make iron and steel should be located near the sources of raw materials.

Read and explain to children a newspaper account of arguments favouring the location of some steel plant at a particular place. Nearness of iron ore deposits and coal deposits are important considerations for such a selection. See Fig. 3-28. Help children to see how difficult it would be for railways to carry all of these raw materials to the plant.

## 4. COAL AND PETROLEUM ARE VALUABLE UNDERGROUND RESOURCES

Besides the metal ores and minerals discussed so far, the earth's crust also contains huge quantities of coal and petroleum. These products have an organic origin. Even so they are often called minerals.

### 4(a). COAL AND PETROLEUM ARE FOUND UNDER GROUND

Besides minerals and metals, the layers of bedrock at some places contain coal or petroleum. The following activities will be found useful to develop this sub-concept.

**Discussion**

**How is coal obtained?**

Show a few pieces of charcoal and coal to the class. Ask them how they are obtained. They know that charcoal is obtained by burning firewood. Help students realize that coal is very different from charcoal. It is very dense—as dense as some pieces of stone are. Show children a picture of a coal mine. Discuss with them how coal, like any other mineral, is obtained by mining. Read to them passages from a suitable story describing the conditions of labour in a coal mine.

*Discuss with children why coal is heavier than wood. (It was compressed by enormous pressure under the earth).*

Children may now be interested to know how petroleum occurs in nature. They already know that underground water is obtained from wells. But, what about petroleum—another liquid from beneath the earth. Like water wells there are petroleum wells too. But mining of petroleum is not so simple as drawing water out of the well. Moreover, petroleum wells are often quite deep, sometimes several thousand feet. The following activity will help children in understanding how petroleum occurs underground.

**Investigation**

**How is kerosene—a product from petroleum—different from water?**

*Materials required*
three vessels,
kerosene,
water

Take kerosene in one vessel and water in another. Let the children observe differences in propertiers of the two liquids. They can easily tell that kerosene has a smell and can burn; also it feels oily. Encourage them to find out which of these two liquids is heavier by putting the two liquids together in a third vessel. Water is evidently heavier since it remains on the bottom, as shown in Fig. 3-29. Now, tell children that kerosene is one of the several products obtained from petroleum. Like kerosene, petroleum is also combustible and has an odour, although it is somewhat different. Petroleum is thicker than kerosene and is usually dark brown or black.

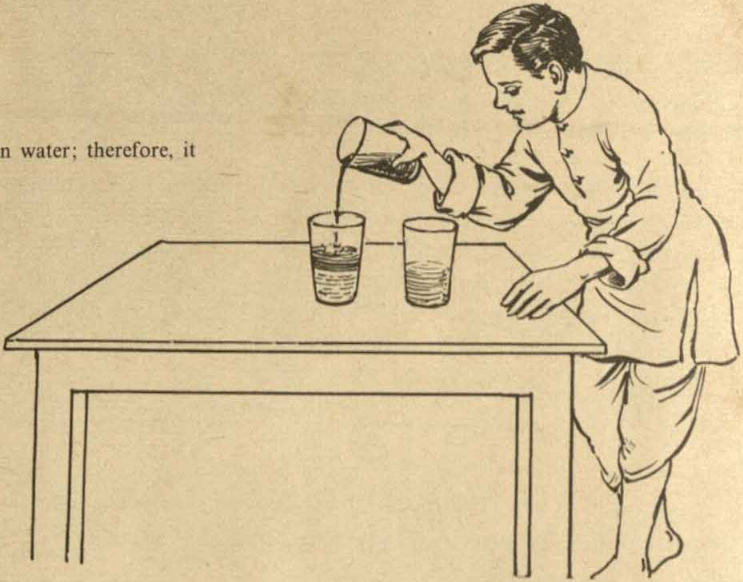


Fig. 3-29
Kerosene is less dense than water; therefore, it floats on water.

**Discussion**

**How does petroleum occur under ground?**

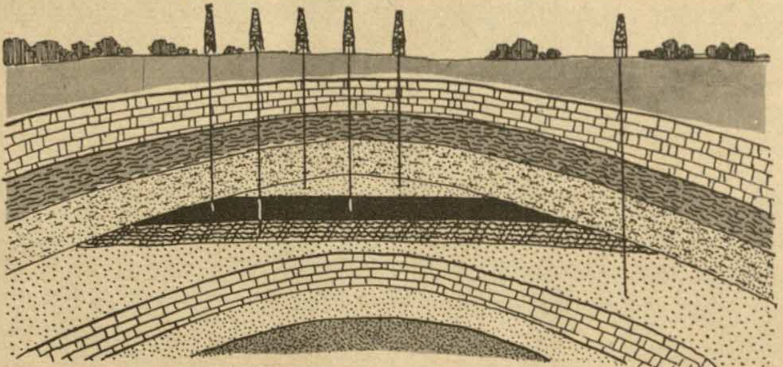


Fig. 3-30
Water, petroleum and gas have different densities; therefore, they often form layers.

Prepare a large sketch similar to Fig. 3-30. Help children observe that oil forms a layer above salt water, and gas lies above the oil layer. This is because water is the heaviest of the three, and gas is the lightest. Petroleum, gas and water accumulate in rocks (e.g. sandstone layers) which are themselves porous but are confined within the layers of non-porous rocks. Petroleum occurs as billions and billions of tiny drops among the pore-spaces of porous rock.

*Discuss with children why it is more difficult and expensive to obtain petroleum than water. Petroleum is not so common as water. Petroleum wells are often very deep. Great skill is required to pump out petroleum from its reservoir of pore-spaces.*

At some places, because of internal pressure, water comes out of the earth's surface in the form of springs. Petroleum rarely comes out of the earth's surface in this way. Even if it does, the pressure soon dies down and pumping is necessary.

### 4(b). PETROLEUM IS FORMED FROM THE REMAINS OF ORGANISMS

Coal and petroleum are not minerals in the strict sense of the word. They are not derived from magma. What, then, is their origin?

Children have learnt how new layers of soil are being deposited over the older ones. Dead plants and animals are buried under these layers. Inside the earth, these dead organisms are subjected to pressure and sometimes to heat. Dead sea animals are also deposited at the bottom. Soil and sand settle down in sea water. Hence there is a layer of dead sea organisms buried with the inorganic sediment. They are subjected to great pressure. Slowly, during the course of millions of years, the dead bodies of these organisms change into petroleum. The following activities will be found helpful to the students in this connection.

**Investigation**

**How does heat slowly change paper?**

*Materials required*
paper,
spirit lamp

Hold a piece of paper sufficiently high above a flame so that it does not catch fire. The paper will first turn brown and then darker and darker in shade. Ultimately it will turn black. Help children in appreciating how heat slowly changes the paper into a black material.

**Investigation**

**How does wood change on heating in a closed vessel?**

*Materials required*
wood pieces,
vessel with a
side tube,
source of heat

Strongly heat small pieces of wood in a closed vessel with an attached side tube, as shown in Fig. 3-31. Show children how wood slowly turns into charcoal by heating and gives forth gaseous and liquid products.

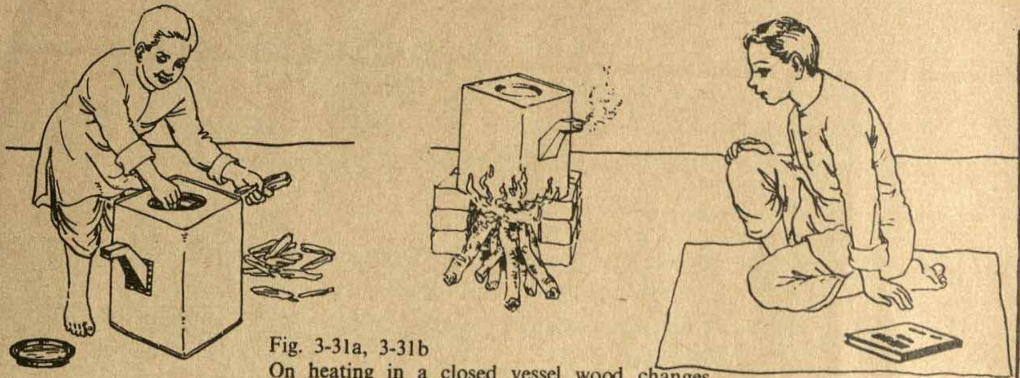


Fig. 3-31a, 3-31b
On heating in a closed vessel wood changes into charcoal and some liquid and gaseous products.

*Discuss with children why wood should be heated in the absence of air for the above experiment. (So that the wood may not burn.)*

*Invite children to hold a white plate in a candle flame. It turns black. In what way is this turning black different from the blackening of paper in the above investigation?*

### 4(c). COAL IS FORMED FROM VEGETABLE MATTER

Millions of years ago large areas of the earth's surface were covered with dense forests—often like very thick swamps. As trees and other plants fell, they were sometimes buried before they had a chance to decay. Over a very long period, and under great pressure, this vegetable matter was transformed into coal. Students can be helped to understand coal formation through activities such as these.

**Discussion**

**How was coal formed?**

Draw Fig. 3-32 on the blackboard and invite children to discuss. Help them to understand how, several million years ago, dense swampy forests covered large areas of the earth. These trees were buried under mud. Then other forests grew over them and were likewise buried. The vegetable matter, thus buried under the earth, was subjected to great pressure and to moderately high temperature. It decomposed through the intermediate stages of peat and liginite into coal. In peat the vegetable matter is only partially decomposed. Peat changed into lignite by the continued effect of great pressure. This process ultimately resulted in the formation of coal.

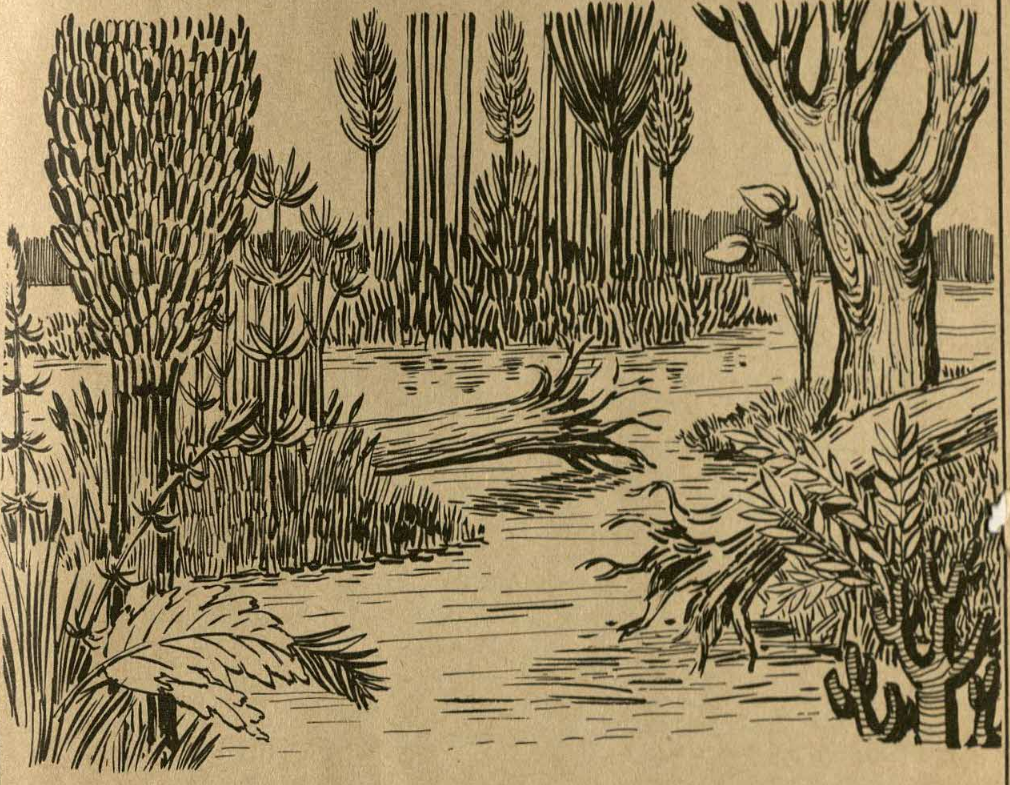


Fig. 3-32
Coal was formed from large, ancient forests which were buried under the mud of the swamps where they grew.

Ordinarily, vegetable matter decomposes in marshy places in a different way. This decomposition is brought about by bacteria in the presence of air. However, the decomposition that produced coal from dead forests over several million years was entirely different. It was caused by the pressure of the over-lying layers of sediments, but in the absence of air. Also the temperature was fairly high. The dead vegetable tissue was preserved between layers of sedimentary rock, often in very thick deposits. Continued pressure gradually changed dead plants into peat, then lignite, then coal. Peat and lignite are not good fuels because they give a great deal of smoke on burning (just as wood does).

**Scientists at Work**

## How does science help find oil?

This is the story of oil—the oil that provides us kerosene for our stoves and lanterns, the petrol for our cars, the vaseline for our cosmetics and ointments, and a host of chemicals of our daily use.

You have seen how a study of the way rocks were formed helps us in classifying rocks into sedimentary, igneous and metamorphic. You know how petroleum originated from the remains of organisms in the rocks. The study of the origin of petroleum appears to be very much unrelated to our lives. But such is the nature of science, that no one can predict how widespread will be the influence of advancement in any area of science. A hypothesis about how petroleum originated beneath the earth helps us in predicting where to look for oil. Many geologists are engaged in this type of work.

You know petroleum has been formed from dead sea animals and plants by very slow geologic processes. Rocks that were once sea beds might have changed into mountains, deserts or plains. An oil geologist goes to the mountains, deserts, plains or even sea beds in search of oil. He is not guided by his whims and fancies in this task but by the knowledge of geology.

Oil originated in what were once marine rocks. Oil being lighter than most of the materials found underneath moved upwards. Only certain rocks—porous rocks—allowed this movement. There were also layers of non-porous rocks which did not allow oil to pass through. Had these non-porous rocks not been there, all oil might have come to the surface and been wasted. Thus we can expect to find oil in a formation of porous rocks that were once under water and are now between layers of non-porous rocks. There the oil is trapped.

Oil geologists are always in search of such oil traps. Photographs of the land surface are taken and studied to help find oil sources. Geologists then go around to map the various rock formations in detail. They are very much interested in places where deep cuts have been made in the earth and inner layers of rock are exposed. Rock samples are collected and examined in the laboratory to find out whether they belong to the types that are expected to bear oil.

Sometimes the oil-bearing rocks are buried very deep. There are instruments that help geologists in anticipating the existence of such rocks without actually digging to that depth.

Even with all this preliminary survey, the existence of oil at a particular place is only a good guess. Actual drilling of wells is done at several places in a promising area. Drilling is a strenuous job. It requires great skill and great expense. Sometimes drilling has to be done under water.

Calculations are made to see whether obtaining oil from the area would be an economic process. Work for actual production starts only when it is found worthwhile.

Oil thus obtained is only the crude oil or petroleum. It is processed through 'refining' to give such useful materials as kerosene and petrol.

Our country is making great efforts to become self-sufficient in petroleum and its products. Our oil-producing areas are located in upper Assam (e.g. Nahorkatiya-Moran) and Gujarat (e.g. Ankleshwar). We have several refineries either in operation or just about to start operation. These include one at Barauni and one at Gauhati.

The location and drilling of oil requires a great deal of scientific research. How could such a remote study as that of oil formation hundreds of millions of years ago be of any practical value? The story of oil illustrates how theoretical scientific research can have great practical value for man.

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